Draft report on the review of information on specific exemptions for decabromodiphenyl ether

Prepared by the intersessional working group of the
Persistent Organic Pollutants Review Committee

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Executive summary

1. At its eighth meeting, the Conference of the Parties to the Stockholm Convention on Persistent Organic Pollutants (POPs) adopted decision SC-8/10, by which it amended Annex A to the Convention to list decabromodiphenyl ether (decaBDE) with various specific exemptions. In addition, the Conference of the Parties adopted decision SC-8/13 on the review of information related to specific exemptions for decaBDE and invited Parties to report to the Secretariat, by December 2019 on the need for the registration of these exemptions.

2. This report compiles the information received in response to the call for information and supplements it with information from national implementation plans (NIP) addressing amendments made at the 8th meeting of the Conference of Parties in 2017, information extracted from the Risk Profile (UNEP/POPS/POPRC.10/10/Add.2), Risk Management Evaluation (UNEP/POPS/POPRC.11/10/Add.1) and the Assessment of additional information on decabromodiphenyl ether (commercial mixture, c-decaBDE) (UNEP/POPS/POPRC.12/INF9/Rev.1). The Secretariat has received responses from nine Parties and three observers.

3. Available production data indicate that about 75 per cent of all the world production of polybrominated diphenyl ethers (PBDEs) was c-decaBDE. Currently c-decaBDE is manufactured only in a few countries. Many countries have already restricted or initiated voluntary programs to phase out the production of c-decaBDE. Production of c-decaBDE no longer takes place in the EU and in the United States. The overall scale of current c-decaBDE production is unknown, as data on production, trade and stockpiles are only available for some countries. None of the Parties who responded to the call for information identified any current production of decaBDE.

4. Commercial decaBDE is a synthetic substance that has been used as an additive retardant in a wide variety of applications such as plastics/polymers/composites, textiles, adhesives, sealants, coatings and inks. DecaBDE containing plastics are used in housings of computers and televisions, wires and cables, pipes and carpets. Even though the production and use of decaBDE is decreasing, products containing this substance are continuously entering waste streams. They can be found in high concentration in some wastes, e-waste in particular. DecaBDE is also found in end-of-life vehicles (ELVs), construction materials and demolition waste, as well as in textile and furniture wastes.

5. For most Parties, the listing of decaBDE came into effect on 18 December 2018. As of 3 February 2020, five parties had registered for specific exemptions. The EU and Switzerland have registered exemptions for both production and use. Both the EU and Switzerland registered exemptions for parts used in legacy vehicles and aircraft. The EU also registered exemptions for decaBDE as additives in plastics and parts in appliances. Brazil registered a specific exemption to allow the importation of parts for use in vehicles until parts without decaBDE are available and can be approved. Iran indicated that decaBDE was still used as an additive flame retardant (FR) and that it is currently used in a variety of applications including in textiles and coatings. New Zealand indicated that due to the large number of older vehicles that are still in circulation, it is necessary to import and/or manufacture parts that contain decaBDE for these vehicles for a number of years. Similarly, a specific exemption would be needed for older aircraft and their spare parts. Japan and New Zealand have submitted notifications of articles in use that contain decaBDE. No Party has registered an exemption for polyurethane foam for building insulation.

6. Limited information on specific exemptions has been provided through the call for information. Of the nine responses were received, three were from Parties that have registered for specific exemptions for decaBDE (Germany and Romania are members of the European Union; and New Zealand). The other six Parties indicate exemptions were either not needed or not applicable. While Egypt indicated that it did not need an exemption, it noted that decaBDE is used in textiles. Only a few Parties have their NIP updated for decaBDE. Of those, one indicated that it would not need an exemption and four indicated that they have yet to determine if specific exemptions would be needed.

7. Limited information was received from the call for information on the extent of current use of decaBDE. DecaBDE has many applications with plastic manufacturing accounting for most of the use. It is also used in textiles. The use of decaBDE is severely restricted in several countries including Canada and members of the European Union. In Australia, which has not yet ratified the amendment to list decaBDE, about 250 t of decaBDE were imported in 2017 for use in plastics, rubber, textiles, and building applications. An industry forecast projects a growth in the market for decaBDE of over 40% between 2018 and 2025.

8. While only two Parties (Japan and New Zealand) have submitted notifications of articles in use to the Secretariat, several Parties indicate that decaBDE enters into their markets in products and articles. Analysis of articles on the market and in waste indicate that decaBDE can frequently be found in products made of recycled plastics. In electric and electronic equipment concentrations range from 10 to 15%. High levels of decaBDE and other brominated FR in plastics is reported to be a barrier to recycling.

9. In light of the available information, possible course of action includes:

(a) Continue to evaluate the need for exemptions and prepare a report for consideration at the eleventh meeting of the COP (in 2023): Overall, there is currently limited information available to inform the review of decaBDE exemptions, therefore another review cycle may be needed. In addition, of the 11 NIPs reviewed, four indicated that an assessment of the need for an exemption had not been undertaken. This would give more time for

Parties to seek guidance (as needed), collect more national information, assess their need for exemptions, and register for these in compliance with the Convention obligations. This would ensure that COP has the necessary information to make an informed decision, in the event that it is asked for an extension to the current time-limitation.

(b) Review exemptions for which no Party has registered and evaluate the need for maintaining such exemptions and prepare a report for consideration at the eleventh meeting of the COP (in 2023): Identifying exemptions for which no Party has indicated a need would allow to remove some exemptions which may no longer be needed.

(c) Encourage Parties to register for the needed exemptions and provide notifications of article in use in compliance with the requirements under the Convention: There is evidence that decaBDE is present in a wide range of articles, yet only two Parties have provided a notification for article in use. In addition, a Party has not registered for an exemption even though it has indicated current use.

(d) Invites Parties that have registered for specific exemptions to provide adequate information on the justification for the continued need for such exemptions to enable the Conference of Parties in undertaking the review of entries in the register of specific exemptions for decaBDE.

(e) Encourage Parties to promote the transition to alternatives: The Risk Management Evaluation (UNEP/POPS/POPRC.11/10/Add.1) concluded that technically feasible alternatives appear to be available for all applications, though for service and replacement of legacy spare parts in articles already in use in vehicles and aircraft is not always practicable. Presence of decaBDE in articles that are recycled can also result in contamination of recycled materials. Parties could be encouraged to:

(i) Promote of the use of known alternatives to decaBDE taking into consideration POPs characteristics or other hazardous properties of these alternatives; , with the recognition that the POPRC has not assessed whether these alternatives meet the Convention's Annex D screening criteria

Commented [EPA1]: It is important to specifically mention the POPRC's role in assessing chemicals based on the Annex D criteria.

(ii) Continue the identification of suitable alternative substances/processes and sharing that information with other Parties via the Secretariat which could then be included in guidance documents on alternatives (UNEP/POPS/COP.9/INF/20); and use of the preliminary draft guidance on preparing inventories (UNEP/POPS/COP.9/INF/18 and UNEP/POPS/COP.9/INF/19/Add.1) to collect national information.

(f) Encourage Parties to take measures to ensure the environmentally sound the management of wastes containing decaBDE: There continues to be widespread presence of decaBDE in articles in use, including articles made from recycled plastics. The presence of decaBDE in plastics is reported to be a constraint to the recycling of plastic products at end-of-life, release of POPs into the environment if they are not disposed of in an environmentally sound manner and can result in the presence of decaBDE in recycled plastics. The continued production and use of products containing decaBDE implies that the latter will be present in the waste stream for a considerable duration.

1. Introduction

10. At its eighth meeting, the Conference of the Parties to the Stockholm Convention on Persistent Organic Pollutants (POPs) adopted decision SC-8/10 which amended Annex A to the Convention to list decabromodiphenyl ether (decaBDE)[1] with various specific exemptions. In addition, the Conference of the Parties adopted decision SC-8/13 on the review of information related to specific exemptions for decaBDE. Specifically, the Conference of the Parties:

(a) Invited each Party listed in the register of specific exemptions for decabromodiphenyl ether listed in Annex A to the Stockholm Convention to report to the Secretariat, by December 2019, justifying its need for the registration of that exemption;

(b) Invited each Party listed in the register of specific exemptions for decabromodiphenyl ether listed in Annex A to the Convention, as well as observers, to provide to the Secretariat, by December 2019, information on the following:

(i) Production;

(ii) Uses;

(iii) Efficacy and efficiency of possible control measures;

(iv) Information on the availability, suitability and implementation of alternatives;

(v) Status of control and monitoring capacity;

(vi) Any national or regional control actions taken; and

(c) Invited all Parties to provide to the Secretariat, by December 2019, information on progress made in building the capacity of countries to transfer safely to reliance on alternatives to decabromodiphenyl ether.

11. In line with paragraphs (a) to (c) of decision SC-8/13 above, the Secretariat sent out letters dated 12 June 2019 and 10 October 2019 inviting Parties and observers to provide information on specific exemptions for decaBDE by 2 December 2019. This information would then be compiled and made available to the POPs Review Committee by January 2020.

12. The Conference of the Parties requested the Committee, subject to the availability of resources, to analyse the information received from Parties and observers and any other pertinent and credible information available and to prepare a report, including any recommendations, for consideration by the Conference of the Parties.

13. At its fifteenth meeting, the Committee adopted decision POPRC-15/4 by which it established an intersessional working group on decaBDE to prepare a report on the review of information related to specific exemptions for decaBDE and adopted a work plan to implement this activity.

14. This report compiles the information received in response to the call for information[2] and supplements it with information from national implementation plans (NIP) addressing amendments made at the 8th meeting of the Conference of Parties in 2017,[3] information extracted from the Risk Profile (UNEP/POPS/POPRC.10/10/Add.2), Risk Management Evaluation (UNEP/POPS/POPRC.11/10/Add.1) and the Assessment of additional information on decabromodiphenyl ether (commercial mixture, c-decaBDE) (UNEP/POPS/POPRC.12/INF9/Rev.1).

2. Register of specific exemptions

15. With its Decision SC-8/10, the Conference of the Parties listed decaBDE in Annex A with the following specific exemptions and inserted a Part IX in Annex A, as follows:

Production:

As allowed for the Parties listed in the Register;

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[1] Also referred to as c-BDE (commercial-decaBDE) or BDE-209.

[2] As of 12 December 2019, the Secretariat had received 12 responses to the request for information, 9 Parties (Belarus, Canada, Egypt, Germany, Monaco, New Zealand, Qatar, Romania, and Senegal) and 3 observers (Canadian Vehicle Manufacturers' Association, European Automobile Manufacturers' Association, and IPEN with the Alaska Community Action on Toxics. The information is available at http://chm.pops.int/TheConvention/POPsReviewCommittee/Meetings/decaBDEandSCCPsubmission/tabid/8255/Default.aspx

[3] Relevant information on decaBDE was extracted from the following NIP updates: Cyprus (2019), Denmark (2018), The Gambia (2019), Kiribati (2019), Liberia (2019), Malawi (2019), Morocco (2019), New Zealand (2018), Spain (2019), Trinidad and Tobago, and Vietnam (2019). NIPs are available at http://chm.pops.int/Implementation/NationalImplementationPlans/NIPTransmission/tabid/253/Default.aspx

Use:

In accordance with the provisions of Part IX of Annex A:

(a) Parts for use in vehicles specified in paragraph 2 of Part IX of this Annex;

(b) Aircraft for which type approval has been applied for before December 2018 and has been received before December 2022 and spare parts for those aircraft;

(c) Textile products that require anti-flammable characteristics, excluding clothing and toys;

(d) Additives in plastic housings and parts used for heating home appliances, irons, fans, immersion heaters that contain or are in direct contact with electrical parts or are required to comply with fire retardancy standards, at concentrations lower than 10 per cent by weight of the part;

(e) Polyurethane foam for building insulation.

Part IX of Annex A:

"1. The production and use of decabromodiphenyl ether shall be eliminated except for Parties that have notified the Secretariat of their intention to produce and/or use it in accordance with Article 4.

2. Specific exemptions for parts for use in vehicles may be available for the production and use of commercial decabromodiphenyl ether limited to the following:

(a) Parts for use in legacy vehicles, defined as vehicles that have ceased mass production, and with such parts falling into one or more of the following categories:

(i) Powertrain and under-hood applications such as battery mass wires, battery interconnection wires, mobile air-conditioning (MAC) pipes, powertrains, exhaust manifold bushings, under-hood insulation, wiring and harness under hood (engine wiring, etc.), speed sensors, hoses, fan modules and knock sensors;

(ii) Fuel system applications such as fuel hoses, fuel tanks and fuel tanks under body;

(iii) Pyrotechnical devices and applications affected by pyrotechnical devices such as air bag ignition cables, seat covers/fabrics (only if airbag relevant) and airbags (front and side);

(iv) Suspension and interior applications such as trim components, acoustic material and seat belts.

(b) Parts in vehicles specified in paragraphs 2 (a) (i)–(iv) above and those falling into one or more of the following categories:

(i) Reinforced plastics (instrument panels and interior trim);

(ii) Under the hood or dash (terminal/fuse blocks, higher-amperage wires and cable jacketing (spark plug wires));

(iii) Electric and electronic equipment (battery cases and battery trays, engine control electrical connectors, components of radio disks, navigation satellite systems, global positioning systems and computer systems);

(iv) Fabric such as rear decks, upholstery, headliners, automobile seats, head rests, sun visors, trim panels, carpets.

3. The specific exemptions for parts specified in paragraph 2 (a) above shall expire at the end of the service life of legacy vehicles or in 2036, whichever comes earlier.

4. The specific exemptions for parts specified in paragraph 2 (b) above shall expire at the end of the service life of vehicles or in 2036, whichever comes earlier.

5. The specific exemptions for spare parts for aircraft for which type approval has been applied for before December 2018 and has been received before December 2022 shall expire at the end of the service life of those aircraft."

16. In its 2016 report, *Decabromodiphenyl ether (commercial mixture, c-decaBDE) Assessment of additional information for the further defining of some critical spare parts in the automotive and aerospace industries and on its use in textiles in developing countries* (UNEP/POPS/POPRC.12/INF/9/Rev.1), the POPs Review Committee (POPRC) recommended that for the automotive industry, the production and use of c-decaBDE should be limited to parts for use in legacy vehicles, defined as vehicles that have ceased mass production, and with such parts falling in one or more of the following categories:

(b) Powertrain and under-hood applications such as: battery mass wire, battery interconnection wire, mobile air-conditioning (MAC) pipe, powertrains, exhaust manifold bushings, under-hood insulation, wiring and harness under hood (engine wiring etc.), speed sensors, hoses, fan modules and knock sensors;

(c) Fuel system applications such as: fuel hoses, fuel tanks, fuel tanks under body;

(d) (c) Pyrotechnical devices and applications affected by pyrotechnical devices such as: air bag ignition cables, seat covers/fabrics (only if airbag relevant) and airbags (front and side).

17. POPRC also noted that generic parts for cars in general are available and noting that some spare parts could possibly be retrofitted to legacy car models, it may be possible to limit the specific exemptions for civilian cars even further than described above.

18. POPRC noted that the available information did not indicate any use of c-decaBDE in the textile production in small and medium size enterprises in developing countries and concluded that there was no apparent need for an exemption for such use. It also indicated that labelling or other means of identification of newly produced articles containing c-decaBDE could be useful when articles become waste. Related information is available in UNEP/POPS/POPRC.12/INF/10 and UNEP/POPS/POPRC.12/INF/11.

19. As of 3 February 2020, Brazil, the European Union (EU), Iran, New Zealand, and Switzerland had registered specific exemptions (see Table 1). The EU and Switzerland have registered exemptions for both production and use. Both the EU and Switzerland registered exemptions for parts used in legacy vehicles and aircraft. The EU also registered exemptions for decaBDE as additives in plastics and parts in appliances. Brazil registered a specific exemption to allow the importation of parts for use in vehicles until parts without decaBDE are available and can be approved. Iran indicated that decaBDE was still used as an additive flame retardant (FR) and that it is currently used in a variety of applications including in textiles and coatings. New Zealand indicated that due to the large number of older vehicles that are still in circulation, it is necessary to import and/or manufacture parts that contain decaBDE for these vehicles for a number of years. Similarly, a specific exemption would be needed for older aircraft and their spare parts.

20. Nine responses to the call for information were received from Parties (Table 2). Germany and New Zealand indicated a need for specific exemptions. The other Parties (Belarus, Canada, Egypt, Monaco, Qatar, Romania, Senegal) indicated that it was either not needed or not applicable. Members of the European Union do not register individually for exemptions as this is done through the European Commission. Two industry observers (the Canadian Vehicle Manufacturers' Association and the European Automobile Manufacturers' Association) noted that specific exemptions for spare parts in legacy vehicles continues to be needed and that the information to substantiate that need had previously been provided to the POPs Review Committee.

21. National implementation plan updates also provide some information. Denmark is not planning to apply for exemptions regarding production and use of decaBDE (Denmark, 2018). The Gambia (2019), Kiribati (2019), Trinidad and Tobago (2018) and Vietnam (2017) have yet to determine if there is a need for specific exemptions.

22. With regard to the exemption in accordance with note (ii) of Annex A to the Convention (articles in use), Japan and New Zealand have provided notifications of articles in use that contain decaBDE (Table 3). While no inventory has been compiled, in their NIP documents, the Gambia (2019), Kiribati (2019), Trinidad and Tobago (2018) and Vietnam (2017) indicate that some existing articles are likely to contain decaBDE.

23. In 2016, the Norwegian Environment Agency commissioned a compilation of information available on c-decaBDE waste and submitted it to the 2017 Conference of the Parties of the Basel Convention (UNEP/CHW.13/INF/14): "Studies show that PBDEs [polybrominated diphenyl ethers] including c-decaBDE occur in recycled materials such as plastic pellets (e.g. [polystyrene] PS and [Acrylonitrile-butadiene-styrene] ABS), carpet padding and isolation materials ([polyurethane] PU foams), plastic toys (several polymers), baby products (that contain PU foams) and food contact articles (FCAs – particularly black colored co-polymers of ABS and [polyethylene-polypropylene] PP-PE). Usually the c-decaBDE related congeners occur in the highest frequencies. This demonstrates that plastics containing PBDEs are being mixed with non-flame-retarded polymers for the production of products/articles which may contribute to human exposure and exposure of sensitive population groups such as children." Concentration levels were reported as follows: in electric and electronic equipment (EEE) 0 to 15% (0 to 150,000 mg/kg); in materials used in some car components 0-2.7% (0 to 27,000 mg/kg); in construction materials, such as electrical insulation and flooring, 0-30% (0 to 300,000 mg/kg); and in textile up to 12% (up to 120,000 mg/kg) (Norway, 2015). Appendix 3 provides information on concentrations of decaBDE found in EEE in Australia.

24. Several Parties, such as Canada, Denmark, Kiribati, and New Zealand, note that decaBDE is likely present in articles on the market. The Gambia has not assessed the presence of decaBDE in the country, but it is likely similar to that of PBDEs which are found in articles and waste streams. A recent investigation of decaBDE, octaBDE[4] and

[4] Octabromodiphenyl ether.

HBCDD in plastics from toys and other consumer products in 19 countries, including Denmark, found decaBDE in 92% of the samples (concentration range: 1-3310 mg/kg), octaBDE in 86% of the samples (1-161 mg/kg) and HBCDD[5] in 41% of the samples (1-207 mg/kg) (Denmark, 2018). This suggests that products made of recycled plastics that are contaminated with brominated FRs, including decaBDE, are present in consumer products sold in Europe. In a survey of shredder waste, all samples were below the detection limit for decaBDE of 100 mg/kg (Denmark, 2018).

[5] Hexabromocyclododecane.

Table 1: Specific exemptions for decaBDE as registered with the Secretariat (as of 3 February 2020)

Activity	Specific exemption	Party	Expiry date	Estimated quantity of production / use	Purpose(s) of production / use	Reason for exemption	Remarks
Use	Parts for use in vehicles specified in paragraph 2 of Part IX of Annex A.	Brazil	At the end of service life of legacy vehicles or in 2036, whichever comes earlier.	Unknown	Parts for use in vehicles specified in paragraph 2 of Part IX of Annex A.	Brazil is working on the development, validation and homologation of parts that do not use BDE-209. It will be necessary to import parts for use in vehicles until the replacement is possible.	DecaBDE is imported under the NCM 2903.99.29 (other halogenated derivatives with only bromine) that represents all halogenated derivatives with bromine. The quantity imported under this NCM code was 150kg in 2018. The automotive sector imports articles with decaBDE, which makes it difficult to estimate the exact quantity used by the sector. Anyway, we are working with the industry to check with their associates in the IMDS (International Material Data System) the amount imported annually by them. At the same time, we are in contact with the Plastic Association to verify the amount of decaBDE imported by this sector.
Production	As allowed for the Parties listed in the Register.	European Union	Not provided		Parts for use in vehicles specified in paragraph 2.(a) (i)-(iii) of Part IX of Annex A, Aircraft for which type approval has been applied for before December 2018 and has been received before December 2022 and spare parts for those aircraft, Additives in plastic housings and parts used for heating home appliances, irons, fans, immersion heaters that contain or are in direct contact with electrical parts or are required to comply with fire retardancy standards, at concentrations lower than 10 per cent by weight of the part.		

Activity	Specific exemption	Party	Expiry date	Estimated quantity of production / use	Purpose(s) of production / use	Reason for exemption	Remarks
Use	Parts for use in vehicles specified in paragraph 2 (a) (i)-(iii) of Part IX of Annex A. Aircraft for which type approval has been applied for before December 2018 and has been received before December 2022 and spare parts for those aircraft. Additives in plastic housings and parts used for heating home appliances, irons, fans, immersion heaters that contain or are in direct contact with electrical parts or are required to comply with fire retardancy standards, at concentrations lower than 10 per cent by weight of the part.	European Union	Not provided		Parts for use in vehicles specified in paragraph 2 (a) (i)-(iii) of Part IX of Annex A. Aircraft for which type approval has been applied for before December 2018 and has been received before December 2022 and spare parts for those aircraft. Additives in plastic housings and parts used for heating home appliances, irons, fans, immersion heaters that contain or are in direct contact with electrical parts or are required to comply with fire retardancy standards, at concentrations lower than 10 per cent by weight of the part.		
Use	Textile products that require anti-flammable characteristics, excluding clothing and toys.	Iran (Islamic Republic of)	18 December 2023	100 tons	Use as fire retardant in textile.	DecaBDE is used as an additive flame retardant and has a variety of applications including textiles, coatings and etc. in Iran.	The date of entry into force of the amendment for Iran will be 18 December 2018.
Use	Parts for use in vehicles specified in paragraph 2 of Part IX of Annex A. Aircraft for which type approval has been applied for before December 2018 and has been received before December 2022 and spare parts for those aircraft.	New Zealand	18 December 2023	Unknown	Parts for use in vehicles specified in paragraph 2 of Part IX of Annex A. Aircraft for which type approval has been applied for before December 2018 and has been received before December 2022 and spare parts for those aircraft.	The average age of the New Zealand vehicle fleet is over 14 years and it will therefore be necessary to import and/or manufacture parts for these vehicles for a number of years. Similarly, a specific exemption would be needed for the relevant aircraft and spare parts for those aircraft.	
Production	Parts for use in vehicles specified in paragraph 2 of Part IX of Annex A. Aircraft for which type approval has been applied for before	Switzerland	Not provided	Unknown	Parts for use in vehicles specified in paragraph 2 of Part IX of Annex A. Aircraft for which type approval has been applied for before	-	-

Activity	Specific exemption	Party	Expiry date	Estimated quantity of production / use	Purpose(s) of production / use	Reason for exemption	Remarks
	December 2018 and has been received before December 2022 and spare parts for those aircraft.				December 2018 and has been received before December 2022 and spare parts for those aircraft.		
Use	Parts for use in vehicles specified in paragraph 2 of Part IX of Annex A. Aircraft for which type approval has been applied for before December 2018 and has been received before December 2022 and spare parts for those aircraft.	Switzerland	Not provided	Unknown	Parts for use in vehicles specified in paragraph 2 of Part IX of Annex A. Aircraft for which type approval has been applied for before December 2018 and has been received before December 2022 and spare parts for those aircraft.		

Table 2: Responses to the call for information on the need for registration of a specific exemption for decaBDE (as of 16 December 2019)

Party	Response
Belarus	Not needed
Canada	Not applicable
Egypt	Not needed
Germany	Germany does not register for specific exemptions; this is done by the European Commission on behalf of the European member states. The relevant information requested in this form will be submitted by the European Commission, too. Germany wishes to confirm that in our country those exemptions for decaBDE that have been included in the POP regulation, namely: "3. By way of derogation, the manufacturing, placing on the market and use of decaBDE shall be allowed for the following purposes, provided that Member States report to the Commission by December 2019 in accordance with the Convention: (a) in the manufacturing of an aircraft, for which type approval has been applied for before 2 March 2019 and has been received before December 2022, until 18 December 2023, or, in cases where the continuing need is justified, until 2 March 2027; (b) in the manufacturing of spare parts for either of the following: (i) an aircraft, for which type approval has been applied for before 2 March 2019 and has been received before December 2022, produced before 18 December 2023, or, in cases where the continuing need is justified, produced before 2 March 2027, until the end of service life of that aircraft; (ii) motor vehicles within the scope of Directive 2007/46/EC of the European Parliament and of the Council, produced before 15 July 2019, either until 2036 or the end of service life of those motor vehicles, whichever date comes earlier; (c) electric and electronic equipment within the scope of Directive 2011/65/EC. 4. The specific exemptions for spare parts for use in motor vehicles referred to in point 2(b)(ii) shall apply for the manufacturing and use of commercial decaBDE falling into one or more of the following categories: (a) powertrain and under-hood applications such as battery mass wires, battery interconnection wires, mobile air condition (MAC) pipes, powertrains, exhaust manifold bushings, under- hood insulation, wiring and harness under-hood (engine wiling, etc.), speed sensors, hoses, fan modules and knock sensors; (b) fuel system applications such as fuel hoses, fuel tanks and fuel tanks under body; (c) pyrotechnical devices and applications affected by pyrotechnical devices such as airbag ignition cables, seat covers/fabrics, only if airbag relevant and airbags (front and side). 5. Use of articles already in use before 15 July 2019 in the Union containing decaBDE shall be allowed. Article 4(2), third and fourth subparagraphs shall apply in relation to such articles. 6. Without prejudice to the application of other Union provisions on the classification, packaging and labelling of substances and mixtures, articles in which decaBDE is used shall be identifiable by labelling or other means throughout its life cycle. 7. The placing on the market and use of articles containing decaBDE imported for the purposes of the specific exemptions in point 2 shall be allowed until the expiry of those exemptions. Point 6 shall apply as if such articles were produced pursuant to the exemption in point 2. Such articles already in use by the date of expiry of the relevant exemption may continue to be used. 8. For the purposes of this entry 'aircraft' means the following: (a) a civil aircraft produced in accordance with a type certificate issued under Regulation (EC) No 216/2008 of the European Parliament and of the Council(3) or with a design approval issued under the national regulations of a contracting state of ICAO, or for which a certificate of airworthiness has been issued by an ICAO Contracting State under Annex 8 to the Convention on International Civil Aviation; (b) a military aircraft."
Monaco	Not needed

Party	Response
New Zealand	Parts for use in vehicles and aircraft: The average age of the New Zealand vehicle fleet is over 14 years and it will therefore be necessary to import and/or manufacture parts for these vehicles for a number of years. These parts may contain decaBDE. Also, New Zealand imports a large number of second-hand vehicles. The average age of these vehicles is such that it is likely they will contain parts incorporating decaBDE. The need for the exemption will diminish as the typical year of manufacture of the imported vehicles rises. Similarly, a specific exemption would be needed for the relevant aircraft and spare parts for those aircraft.
Qatar	Not applicable
Romania	Not applicable
Senegal	None

Table 3: Notifications of articles in use containing decaBDE pursuant to note (ii) of Annex A of the Stockholm Convention (as of 12 December 2019)

Party	Chemical	Article in use	Date of notification	Any comments linked to actual notification
Japan	Decabromodiphenyl ether (BDE-209) present in commercial decabromodiphenyl ether	- Flame-retardant treatment agent - Flame-retardant materials for automobiles, aircrafts, and railway vehicles - Flame-retardant materials for building and equipment - Flame-retardant textiles - Flame-retardant adhesives and sealing filters - Flame-retardant plastic cases for home appliances.	28/11/2018	
New Zealand	Decabromodiphenyl ether (BDE-209) present in commercial decabromodiphenyl ether	Articles where decaBDE has been used as an additive in plastics (such as in electrical and electronic equipment, wires, cables and pipes), in textiles (such as in carpets, upholstery, window blinds and curtains and mattresses), and in adhesives, sealants and coatings - present in New Zealand before 18 December 2018.	14/12/2018	

3. Information on the production and use of decaBDE

Production and importation

25. None of the countries who responded to the call for information identified any current production of decaBDE (Table 4). It was never produced in Belarus, Canada, Egypt, Monaco, New Zealand, Qatar and Senegal. In Canada decaBDE production is prohibited under the *Prohibition of Certain Toxic Substances Regulations, 2012*. (Canada, 2019b). Based on their NIP, decaBDE was never produced in Denmark, the Gambia, Kiribati, or Spain. DecaBDE was never produced in Australia (Australia, 2019). In Australia in 2004, imports of decaBDE were 234 t, which decreased to 73 t in 2008. Since then imports have increased to over 250 t in 2017. As noted above, the European Union registered specific exemptions for both production and use. Until 2017, small amounts of FR masterbatches containing decaBDE were imported into New Zealand (New Zealand, 2018). Historically, about 5 t/year of decaBDE would have been imported into Denmark (Denmark, 2018). Several countries noted that the majority of decaBDE enters as a component of imported products.

26. Available production data indicate that about 75 per cent of all the world production of PBDEs was c-decaBDE. Currently c-decaBDE is manufactured only in a few countries. Many countries have already restricted or initiated voluntary programs to phase out the production of c-decaBDE. Production of c-decaBDE no longer takes place in the EU and in the United States. Total production of c-decaBDE from 1970 to 2005 has been estimated at

between 1.1 and 1.25 million tonnes. The overall scale of current c-decaBDE production is unknown, as data on production, trade and stockpiles are only available for some countries. Production of c-decaBDE is still ongoing in a few countries (e.g. China and India). The annual production capacity of decaBDE in China in 2013 was reported as 49,000 tons (UNEP/CHW.14/7/Add.3/Rev.1).

27. One observer, IPEN, referred to a July 2019 press statement: "The decabromodiphenyl ether market is forecast to rise from USD 300 million in 2018 to around USD 430 million by 2025, according to a 2019 Global Market Insights, Inc. report."[6] IPEN also lists the following companies as potential producers of decaBDE: China: Shandong Haiwang Chemical, Shouguang Weidong Chemical, UNIBROM Corp., Wingar Fengtai Chemical; Europe: ICL-IP; India: Acuro; Japan: Tosoh; and USA: AccuStandard. It also notes the following companies as manufacturers of brominated substitutes: China: Shandong Haiwang Chemical (DBDPE), tetrabromobisphenol A bis (2,3-dibromopropyl ether (TBBPA) and others), Shouguang Weidong Chemical (DBDPE and other brominated FRs), SULI (DBDPE), UNIBROM Corp (DBDPE, TBBPA, and others), Wingar Fengtai Chemical (DBDPE, hexabromocyclododecane (HBCDD), TBBPA, and others); and USA: AccuStandard (a variety of PBDEs).

Table 4: Responses to the call for information on national production and use of decaBDE (as of 12 December 2019)

Party	Production	Uses
Australia	None Imports of decaBDE from 2004 to 2017 were as follows: 2004 234.0 2005 208.3 2006 222.5 2007 185.0 2008 73.0 2009 119.0 2010 223.0 2011 238.0 2017 250.8 (Australia, 2019).	DecaBDE is used by plastics compounders as an additive flame retardant in a variety of resins. The main resins are acrylonitrile-butadiene-styrene (ABS), low density polyethylene (LDPE) and high impact polystyrene (HIPS): Approximately 123 t used in plastic products in 2017; Approximately 56 t in the formulation of textile coatings in 2017; 18 t/year for conveyor belts for use in mines and as seals around air ducts in mine ventilation systems; Approximately 20 t/year in paper foil laminate in home insulation; and Nearly 54 t/year in architectural foam (Australia, 2019).
Belarus	None	DecaBDE (tradename FR-1210) has been used for production of heat resistant composite polymers (based on polyethylene terephthalate) for the manufacture of items for electro-technical purposes. The volume of use: 2015 – 4.3 t; 2016 – 3.2 t. The content of decaBDE in polymer is about 7%.
Canada	DecaBDE has never been produced in Canada and the production is prohibited under the *Prohibition of Certain Toxic Substances Regulations, 2012*. (Canada, 2019b)	Since December 2016, the manufacture, use, sale, and import of decaBDE and products that contain decaBDE are prohibited in Canada by the *Prohibition of Certain Toxic Substances Regulations, 2012*, with limited exemptions (Canada, 2019b). Currently there is an exemption for manufactured items (i.e. an item that is formed into a specific physical shape or design during its manufacture and that has, for its final use, a function or functions dependent in whole or in part on its shape or design). In Canada, the known uses of decaBDE are limited to imported manufactured items containing decaBDE. Manufactured items which may contain decaBDE are imported into Canada for use in the following sectors: transportation, electrical and electronic equipment, upholstered furniture and textiles. DecaBDE may also be present in recycled plastics and automotive shredder residue.

[6] https://www.businesswire.com/news/home/20190625005422/en/Decabromodiphenyl-Ether-Market-worth-USD-430-Million (Accessed 2019-12-31).

Party	Production	Uses
		The three main manufacturers of the decaBDE commercial mixture operating in the United States voluntarily ceased exports of the decaBDE commercial mixture to Canada in mid-2012. For additional information, please refer to the *Canadian Ecological Screen Assessment Report on Polybrominated Diphenyl Ethers* (Canada, 2006).
Egypt	Not produced in Egypt	Used as flame retardants in plastic and textiles manufacture
Germany	No information provided	No information provided
Monaco	None	Not used
New Zealand	None	No uses in New Zealand other than in spare parts for vehicles and aircraft.
Qatar	None	Not used
Romania	Not applicable	Not applicable
Senegal	None	Not used

Use of decaBDE

28. Commercial decaBDE is a synthetic substance with no known natural occurrence that has been used as an additive retardant in a wide variety of applications such as plastics/polymers/composites, textiles, adhesives, sealants, coatings and inks. DecaBDE containing plastics are used in housings of computers and televisions, wires and cables, pipes and carpets (UNEP/POPS/POPRC.10/10/Add.2). The Risk Management Evaluation (UNEP/POPS/POPRC.11/10/Add.1) notes: The plastics industry is by far the major user of fire retardants (FR) and the largest quantities of FR are supplied to raw-material manufacturers. The amount of c-decaBDE used in plastics and textiles in various countries varies, but up to 90% of c-decaBDE ends up in plastic and electronics, while the remaining ends up in coated textiles, upholstered furniture and mattresses.

29. EEE applications of c-decaBDE include equipment casing, wires and cables, and small electrical components. Other identified uses of flame-retarded plastics are in buildings, construction materials, in storage and distribution products such as plastic pallets, in the transportation sector (cars, airplanes, trains and ships). The aviation industry still uses c-decaBDE in electrical wiring and cables, interior components, and EEE of older airplanes and spacecrafts (UNEP/POPS/POPRC.11/10/Add.1). Information available to the POPs Review Committee indicated that while the consumption of commercially available decaBDE peaked in the early 2000s, it was still extensively used worldwide (UNEP/POPS/POPRC.10/10/Add.2).

30. The following uses were identified in the responses to the call for information (Table 4). In Belarus, decaBDE has been used in the production of heat resistant polyethylene terephthalate composite polymers for the manufacture of EEE at a concentration of about 7% in the finished product. The amount used was 4.3 t in 2015 and 3.2 t in 2016. In Canada, the known uses of decaBDE are limited to imported manufactured items containing decaBDE in the transportation, electrical and electronic equipment, upholstered furniture and textiles sectors. DecaBDE may also be present in recycled plastics and automotive shredder residue. In Egypt, decaBDE is used as flame retardants in plastic and textiles manufacture. The only use in New Zealand is in spare parts for vehicles and aircraft.

31. Information on the consumption in the EU is not available. DecaBDE was considered the most cost-effective all-round brominated FR in polymeric applications and textile applications. The most recent information on use of decaBDE in Denmark dates from 1999. At that time, decaBDE and other PBDEs were largely phased out in the production of plastic for electronics in Denmark. While consumption of decaBDE was not separately estimated, it made up the majority of the 10-120 tons of PBDE used. Most of the PBDE was imported within articles. Since 2008, decaBDE has been banned in EEE with certain exemptions which have now been repealed (Denmark, 2018).

32. In Australia, use of decaBDE imported as raw chemical or in dispersions in 2017 was 123 t or 49.0% of the total use in plastics, 18 t (7.2%) in rubber, 56 t (22.3%) in textiles, and 54 t (21.5%) in building applications (Australia, 2019). Uses include resins that are used in the manufacturing of articles used in the electrical, automotive and building industries. Examples of such end articles are: fan housings; brackets; electrical housings; building panels; traffic lighting surrounds; ducting; scuff protectors; cable wiring; heat-shrink tubing for joining electrical cables; casings for electrical equipment (such as hot water units; automotive backcasing behind instrumentation; hopper bowls of poker machines; in mounts and brackets of casings); electrical boxes; capacitor covers; air conditioning ducting; foam insulation in transport vehicles; insulating foam in building walls (Australia, 2019).

33. The Australian rubber industry uses decaBDE for the manufacture of rubber conveyor belts and ventilation bands used as seals in mine ventilation systems. DecaBDE is also used in textile manufacturing: in coatings for curtains and upholstery fabrics (such as hotel curtains, public seating (aircraft seating, automotive and public transport upholstery), and hospital chairs), rainwear apparel, and carpet backing. In the Australian construction industry, decaBDE can be used in paper foil laminate in home insulation, as part of coatings on house architectural decorations and in the formulation of hot melt adhesives (Australia, 2019).

34. Appendix 2 provides an overview of uses reported under the REACH Regulation by the building and construction, textiles and furniture, transport, and electric and electronic equipment sectors in Europe.

35. More information on the uses of decaBDE is available in the Appendix 1 and the Risk Management Evaluation (UNEP/POPS/POPRC.11/10/Add.1).

DecaBDE in articles

36. Tables 5 and 6 summarize the use and concentrations of decaBDE in various articles. In EEE concentrations range from 10 to 15% (effective concentration from 2 to 32%), though concentrations as high as 72,000 mg/kg have been reported (Norway 2015). In articles used in the transportation sector concentrations ranged from not detected (n.d.) to 27000 mg/kg. Many car parts do not contain decaBDE. The highest levels were found in seat cover materials (Norway, 2015).

37. In the UK, the Industry Council for Electronic Equipment Recycling (ICER), in cooperation with the UK government and the Environment Agency, recently investigated the presence of chemicals used as flame retardants in more than 2000 items of WEEE. This analysis confirmed there are often high levels of hazardous chemicals including PBDEs present in plastic components, particularly in display devices and small-mixed WEEE. The results are expected to be published in the second quarter of 2020.

38. DecaBDE is present in plastic waste and recycled materials in the Netherlands. DecaBDE (BDE 209) is usually the predominant BDE congener found in waste plastic and plastic product samples including in recycled materials. A mass flow analysis for the Netherlands focusing on POP-BDEs (including hexa-, hepta-, tetra and penta-BDE) and decaBDE, showed that 22% of all POP-BDE in E-waste is expected to end up in recycled plastics because they are not effectively separated out of plastic waste streams (UNEP/CHW.13/INF/14). Leslie and colleagues (2016, as cited in UNEP/CHW.13/INF/14) found both POP-BDE and decaBDE in carpeting and insulation materials made from recycled materials. Concentrations of decaBDE were as high as 0.8 mg/kg (0.00008%). They also reported that a quarter of the toys sampled contained PBDEs, with concentrations up to 44 mg/kg (0.0044%) for POP-BDEs and up to 800 mg/kg (0.08%) for decaBDE.

39. An analysis of over 1 700 consumer products available for sale in 2012 in Australia detected the presence of bromine in 51% of the measurements taken. In 28% of the measurements, levels of bromine were found to be above 1 000 ppm and in 10% bromine levels were greater than 10 000 ppm (Gallen et al., 2014). As most of the levels measured were below 10 000 ppm this suggest that recycle plastics are the source of the brominated FR (Gallen et al., 2014). This study also assessed the presence of FR through surface dust and analysis of extracts using gas chromatography/mass spectrometry (GC/MS). Of the 139 wipes analysed, different PBDEs were detected in 83 wipes (61%). The congener most frequently identified was BDE-209 (68 wipes or 50%). Televisions, powerboards and adaptors and computer monitors had the highest proportions of wipes where BDE-209 was detected. The highest level of BDE-209 found was 14 µg per wipe. Some wipes were also taken of EEE where bromine was not detected by X-ray fluorescence (XRF). Low levels of brominated FR were detected in 9 (56%) of these wipes. BDE-209 was the most frequently detected FR with maximum concentration of 340 ng per wipe. In the samples that were analysed by GC/MS, BDE-209 was the most frequently detected and contributed to between 65% and 100% of the total PBDEs detected. The highest concentration measured (88,600 µg/g or 8.9% w/w) was from the back panel of a flat screen television. More details are found in Appendix 3.

40. Previous studies have found PBDEs in recycled carpet padding (DiGangi et al., 2011), children's toys on the EU market (DiGangi and Strakova, 2016; Guzzonato et al., 2017; Ionas et al., 2014) and food contact articles on the EU market (Kuang et al., 2018; Puype et al., 2015; Samsonek and Puype, 2013) indicating widespread recycling of electronic waste (Turner and Filella, 2017). In a study of brominated flame retardants in plastic toys purchased in South China, including deca-BDE, the brominated FR profiles in the toys were consistent with the patterns of production and consumption in China, where PBDEs, specifically decaBDE, were the dominant brominated FR, followed by the emerging decabromodiphenyl ethane (DBDPE) (Chen et al., 2009). A 2019 study of organohalogen flame retardants in the plastic casings of televisions found deca-BDE in all three Insignia televisions tested, and deca-BDE was found at concentrations above U.S. State of Washington enforcement limit of 0.1% in the Insignia Roku 50-inch television (Schreder and Uding, 2019).

Table 5: Uses and concentrations of decaBDE in the EEE (Norway, 2015)

Identified uses / part / material	Concentration	Source
Plastics	10-15% w/w	ECHA, 2014 (citing UK HSE, 2012)
FR2 laminates	36 g/m2	ECHA, 2014 (citing SAEFL, 2003)
PE insulating foam	20 g/kg	ECHA, 2014 (citing SAEFL, 2003)
PE plastic sheeting	100 g/kg	ECHA, 2014 (citing SAEFL, 2003)
PP plastic sheeting	100 g/kg	ECHA, 2014 (citing SAEFL, 2003)
PVC plastic sheeting	50 g/kg	ECHA, 2014 (citing SAEFL, 2003)
Heat shrinkable products	10% w/w	ECHA, 2014 (citing Danish EPA, 2007)
Plastics from EEE products	n.d. to 72,300	IVM and IVAM, 2013
Computer display casing	1,5 mg/kg (n.d. and 6.08, min./max)	Chen et al., 2010
TV casing	8 mg/kg (n.d. and 45.6, min./max)	Chen et al., 2010
Computer component	254 mg/kg (n.d. and 1513, min./max)	Chen et al., 2010
EEE materials	72 and 191 mg/kg (min./max.)	Binici et al., 2013
PC boards	16 mg/kg	Kajiwara et al., 2011
Rice cooker 1	11 mg/kg	Kajiwara et al., 2011
Rice cooker 2	0.3 mg/kg	Kajiwara et al., 2011
Computer mouse	0.55 mg/kg	Kajiwara et al., 2011
Motherboard computer	11584 mg/kg	Kumari et al., 2014
Electrical wires	n.d.	Kumari et al., 2014
Lamp	> 0.1 %	Kant. Lab. BS, 2009
Consumer electronic device	> 0.1 %	Kant. Lab. BS, 2009
Av. Concentration in small size EEE	510 mg/kg *	Morf et al., 2005
Casings of computer monitors	40 mg/kg	Li et al., 2013 (citing Zennegg et al., 2014)
Casings of TVs	100 mg/kg	Li et al., 2013 (citing Zennegg et al., 2014)
Plastic parts from small E-waste	1800 mg/kg	Li et al., 2013 (citing Morf et al., 2005)
CRT TVs and monitors	500 and 3000 mg/kg (min./max.)	Wäger et al., 2010
Office equipment	500 and 3000 mg/kg (min./max.)	Wäger et al., 2010 (citing Tange and Slijkhuis, 2009)
Refrigerators	n.d. and 1000 mg/kg (min./max.)	Wäger et al., 2010 (citing Tange and Slijkhuis, 2009)
White goods	n.d. and 1000 mg/kg (min./max.)	Wäger et al., 2010 (citing Tange and Slijkhuis, 2009)
Small domestic appliances	n.d. and 1000 mg/kg (min./max.)	Wäger et al., 2010 (citing Tange and Slijkhuis, 2009)
remainder ICT equipment	n.d. and 1000 mg/kg (min./max.)	Wäger et al., 2010 (citing Tange and Slijkhuis, 2009)
mixed plastics from CRT monitors	av. 3200 mg/kg (max. 7800 mg/kg)	Wäger et al., 2011
CRT TVs	av. 4400 mg/kg (max. 7800 mg/kg)	Wäger et al., 2011
PC CRT screens	av. 8600 mg/kg	Sindiku et al., 2014
TV CRT screens	av. 57000 mg/kg	Sindiku et al., 2014

* This concentration corresponds to a Swiss study carried out in 2003. A follow-up study was done in 2011 (Taverna et al. 2017) which found an average concentration of 390±45 mg/kg.

Table 6: Uses and concentrations of decaBDE in the transport sector (Norway, 2015)

Identified uses / part / material	Concentration	Source
Cars	0.625 g/kg	ECHA, 2014 (citing SAEFL, 2003)
Cars	1-5 g/car	ECHA, 2014 (citing Danish EPA, 2007)
Cars	<1-<10 mg/kg car	ECHA, 2014
Rail vehicles	85 g/kg	ECHA, 2014 (citing SAEFL, 2003)
Seat foam from ELVs	n.d.	BMRA, 2013
Seat fabric from ELV	n.d.	BMRA, 2013
PUF Pontiac 1997	522 mg/kg	IVM and IVAM, 2013
Seat cover Pontiac 1997	22500 mg/kg	IVM and IVAM, 2013
Interior Pontiac 1997	18 mg/kg	IVM and IVAM, 2013
PUF Mazda 1998	n.d.	IVM and IVAM, 2013
Seat cover Mazda 1998	22700 mg/kg	IVM and IVAM, 2013
Interior Mazda 1998	52 mg/kg	IVM and IVAM, 2013
PUF from US car seats	0.11 and 17 mg/kg (min. and max.)	IVM and IVAM, 2013
Different car components	n.d.	IVM and IVAM, 2013
Car seats	n.d. and 131 mg/kg (min. and max.)	IVM and IVAM, 2013
Car seat cover	256 mg/kg	IVM and IVAM, 2013
PUF from old car seats	n.d. and 2.1 mg/kg (min. and max.)	Niinipuu, 2013
Soundproofing material sample 1	n.d.	Mepex, 2012
Soundproofing material sample 2	7000 mg/kg	Mepex, 2012
Airbag material	n.d.	Mepex, 2012
Seat cover material	27000 mg/kg	Mepex, 2012
Interior material (door, headlining, cover)	17000 mg/kg	Mepex, 2012
Luggage compartment material	n.d.	Mepex, 2012
Radiator, outer material	n.d.	Mepex, 2012
Printed circuit boards sample 1	200 mg/kg	Mepex, 2012
Printed circuit boards sample 2	n.d.	Mepex, 2012
Printed circuit boards sample 3	n.d.	Mepex, 2012
Printed circuit boards sample 4	33 mg/kg	Mepex, 2012
Car interior	n.d.	Ballesteros-Gomez et al., 2013
Car interior	8 mg/kg (n.d. to 32.6, min./max.)	Chen et al., 2010
car interior foam (grey foam, dark grey foam and rubber filling) and different types of car interior materials (fabric seat cover, brown cushion foam in car seat)	n.d.	Shin and Baek, 2012

Table 7: Uses and concentrations of decaBDE in the building and construction sector (Norway, 2015)

Identified uses / part / material	Concentration	Source
Electrical insulation	10-30%	ECHA, 2014
Epoxy adhesive	< 30%	ECHA, 2014
PVC flooring	n.d.	Kumari et al., 2014
Damp-proof membrane/film	> 0.1%	Kant. Lab. BS, 2009

Table 8: Uses and concentrations of decaBDE in textiles and furniture (Norway, 2015)

Identified uses / part / material	Concentration	Source
Tents	2 g/tent	ECHA. 2014 (citing Danish EPA (2007)
Identified uses / part / material	Concentration	Source
Adhesive layer of reflective tapes	1-5% w/w	ECHA, 2014
Velour pile fabrics (70-80 g/m2)	21-32 g/m2	ECHA, 2014 (citing ECB, 2002)
Cotton (30-40 g/m2)	9-16 g/m2	ECHA, 2014 (citing ECB, 2002)
Flat woven (30-80 g/m2)	9-32 g/m2	ECHA, 2014 (citing ECB, 2002)
Various textiles	1.55-6.42 %	ECHA, 2014 (citing Earls, 2007)
Carpet	79 and 90 mg/kg (min./max.)	Binici et al., 2013
Household curtains of three different colours, three kinds of car interior foam (grey foam, dark grey foam and rubber filling), and three different types of car interior materials (fabric seat cover, brown cushion foam in car seat)	n.d.	Shin and Baek, 2012
Window blind	4,799 mg/kg	Kumari et al., 2014
Upholstery foam	7,023 mg/kg	Kumari et al., 2014
Commercial decaBDE treated polyester upholstery textiles used in curtain manufacture	120 g/kg (ΣPBDEs: 130 g/kg)	Kajiwara and Takigami, 2013

DecaBDE in waste

41. Even though the production and use of c-decaBDE is decreasing, products containing this substance are continuously entering waste streams. They can be found in high concentration in some wastes, e-waste in particular (UNEP/CHW.13/INF/14; (UNEP/POPS/POPRC.11/10/Add.1). DecaBDE is also found in end-of-life vehicles (ELVs), construction materials and demolition waste, as well as in textile and furniture wastes. Data from Europe for the period 2003-2014 showed concentrations ranging from 0 to 0.3% (3,000 mg/kg) with higher levels found in cathode ray tube (CRT) televisions and monitors and in office equipment. Other e-waste categories had concentrations below 1000 mg/kg. Levels in samples collected in 2011 in Nigeria were 0.08% (800 mg/kg) in computer CRT screens and 0.86% (8,600 mg/kg) in television CRT screens (Norway, 2015; UNEP/CHW.13/INF/14).

42. In its NIP update, Denmark notes that most of the decaBDE entered the country as a constituent of manufactured goods, largely in components of EEE, vehicles and building materials. While the use of decaBDE in EEE has ceased as a result of the European directive on the restriction of the use of certain hazardous substances in EEE, articles where decaBDE was used as a FR are likely present in Danish society; these are disposed of primarily as solid waste (Denmark, 2018).

43. In a study commissioned by the Norwegian Environment Agency (Martin and Nilsson, 2018) post-consumer plastics destined for recycling were analysed for total bromine, c-decaBDE and other PBDEs. Levels of c-decaBDE in plastic waste streams from electric and electronic equipment waste (WEEE) and ELVs in different European countries were assessed. Out of the 50 samples analysed using XRF, 21 of these samples had Br levels above 500 ppm. Of the 50 samples, 25 samples were also analysed using gas chromatograph-mass spectrometry (GC-MS); BDE-209 was detected in 22 of those samples. The highest concentration measured was 900 ppm BDE-209 in the unseparated reference sample from a television casing. In the materials that had been separated, the highest measured concentration of BDE-209 was 280 ppm in plastic from a small domestic appliance. Overall, this study suggests that post-consumer plastics that have undergone sorting and separation in the state-of-the-art recycling facilities are likely to contain no or low levels of c-decaBDE (< 1000 ppm). There are inherent differences in the measurement methods between GC-MS and XRF. The first measures the concentration of specific brominated compounds, and the second, the concentration of bromine atoms. Some samples with low levels of PBDEs were found to contain high levels of total bromine. The bromine in those samples is likely from other brominated FRs that are still available on the market.

44. In 2015, 146,571 tons of e-waste was collected in Norway (UNEP/CHW.13/INF/14). While bromine containing plastic can be identified by experience or XRF analysis and removed at the disassembly stage, most of the

plastics that contain decaBDE is removed as part of the shredder light fraction of the waste. This fraction can either be sent directly to an energy recovery facility or further separated though sink/float or sensor-based separation. The bromine containing fraction is then removed. The mixed plastic fraction from fridges contains very low levels of decaBDE. In contrast, the plastics from small electronic appliances has a much higher content of decaBDE. Using sink/float separation, one company reported that 28% of the plastic from e-waste is separated out as bromine-containing plastic. Another company reported the proportion separated and treated as if it contained bromine was 40%. In a company using sensor-based technology the proportion of bromine containing plastic removed was 20%. In all cases, plastics identified as containing bromine are sent to a facility for energy recovery.

45. In Norway, car collection facilities are responsible for removing parts for reuse, as well as potentially hazardous components such as oil, fuel, airbag explosives, batteries, and tires. Once these items are removed, the car is then prepared for shredding. Data from 2015 show that the average car weighed 1 148 kg, of which 101 kg were removed before shredding. Once shredded, the mass of the shredded light fraction that contains plastic materials was 182 kg. Forty-five percent of this was sent for energy recovery, 35% for material recovery and 1% landfilled. The average content of decaBDE in the shredded light fraction waste was 48.4 mg/kg (UNEP/CHW.13/INF/14).

46. In 2011, a sample weighing 220 t of representatively composed e-waste was processed in a Swiss recycling facility. The different output streams were analysed. The highest fractions of decaBDE mass flow were in fine-grained plastics (51%) and in monitor and notebook casings (41%), with concentrations of 860±170 mg/kg and 3300±170 mg/kg, respectively. The overall decaBDE concentration in e-waste was 390±45 mg/kg. This translates into an annual decaBDE mass flow of 27±6 tonnes/year in all Swiss e-waste generated in 2011. There was no change in the mass flows between 2003 and 2011, whereas the concentrations decreased by 24% during the same period (Taverna et al., 2017).

47. In the EU, a majority of decaBDE content in existing article is constantly being destroyed through incineration of WEEE plastics that have high bromine content. However, an important portion is recycled and thus finds its way into products and re-enters waste streams. Given that the consumption of decaBDE in the EU has declined since 2010, it can be expected that decaBDE levels in EEE waste will start to decrease starting in the late 2010s and through the 2020s. Only low levels of decaBDE are expected to remain in WEEE after 2030 (Potrykus et al, 2019). DecaBDE in expected to continue to be present in ELV waste until the end of the 1930s. Given the lifetime for buildings is around 50 years, waste containing decaBDE from the construction and demolition sector will enter the waste stream around 2020 and is expected to reach a plateau between 2040 and 2060. Potrykus and colleagues (2019) estimate that by that time, approximately this construction sector would contribute 1,500 tonnes of decaBDE to the waste stream. Recycling rates for plastic-based building products containing decaBDE is currently low. Appendix 4 provides a compilation of concentrations decaBDE found in materials, articles in and waste.

4. Information on the efficacy and efficiency of possible control measures for decaBDE

48. Information received on efficacy and efficiency of possible control measures is found in Table 9. Canada indicated that it is developing proposed amendments to the *Prohibition of Certain Toxic Substances Regulations, 2012* (Canada, 2018b). These amendments would remove the exemption for manufactured items and impose a phase-out schedule for automotive parts to align with the listing of decaBDE in Annex A of the Convention. New Zealand only allows the use of decaBDE in parts for legacy vehicles and aircraft as outlined in Annex A of the Convention. It anticipates the use of parts containing decaBDE will decline overtime as the older vehicles and aircraft are taken out of service. Senegal indicates limited capacity is available in the country and Egypt has undertaken capacity building and awareness programs.

49. The main source of decaBDE in waste in Denmark is EEE, building materials, and shredder waste. As decaBDE was used in EEE in Denmark until 2008 and for other applications until recently, it is likely to be found in the waste stream for many years still. Plastic waste in Denmark is likely disposed primarily to municipal waste incinerators. However, there is an increased focus on the recycling of plastics (Denmark, 2018). Denmark (2018) notes that the major challenge with the management of decaBDE is its presence in waste and recycled plastics. There is a risk that ineffective sorting of plastic waste can result in products being made with recycled plastic that are contaminated with decaBDE.

50. In Denmark, plastic from WEEE that include components with more than 5 mg/kg (ppm) of brominated FRs must be disposed of by companies approved for the handling of bromine-containing waste. There is little final treatment of WEEE in Denmark, though some pre-sorting of the waste takes place. In 2017 approximately 45,000 tons of WEEE were processed in Denmark with about 25,000 tons sent for disposal in other EU Member States. No waste has been registered as treated outside the EU since 2008 (Denmark, 2018).

51. DecaBDE in textiles used in cars ends up in shredder waste (Denmark, 2018). There is interest in incinerating shredder waste to recover the energy content from the waste rather than just sending it to landfill. However, more data

are needed to assess if incineration of this waste can meet the required destruction efficiency for decaBDE and other POPs that are found in them (Denmark, 2018).

52. A barrier to recycling WEEE, building materials and vehicles is the presence of decaBDE and other brominated FR associated with the thermoplastics in these products (Denmark, 2018). The screening methods used to separate the waste usually only distinguish between plastics that do or do not contain bromine and does not distinguish the specific compounds found in the plastic. Given the widespread application of FR in plastics, the dissemination of additional information on the specific applications of these substances is not likely to facilitate recycling. The Danish Ministry of Environment and Food suggests that further recycling of plastics containing brominated FRs needs to wait until decaBDE and other brominated FRs of concern are out of the waste stream (Denmark, 2018). In the meantime, the Ministry plans to introduce additional restrictions on existing products that contain PBDEs, including decaBDE, and to assess how materials with PBDEs can be separated from the waste stream prior to recovery and other waste treatment.

53. Gallen and colleagues (2014) used three methods to screen consumer products for brominated FRs, including decaBDE. They concluded that in spite of the limitations of each method, combining the XRF with wipe testing could be a useful way to identify products that contain BDE-209. An initial screening using XRF could identify products likely to contain a brominated FR. A surface swipe of the article can then be used to identify the specific FR present with an accuracy of greater than 80%.

54. The observer IPEN highlights two efficient methods to reduce emissions of decaBDE and other harmful substances from waste: non-combustion methods of destruction as described in the *Basel Convention General technical guidelines on the environmentally sound management of wastes consisting of, containing or contaminated with persistent organic pollutants* (UNEP/CHW.14/7/Add.1/Rev.1) and the use of a protective level for low-POPs content.

55. IPEN notes that the widespread contamination of recycled plastics with brominated fire retardants is undermining the transition to a circular economy. Therefore, the most efficient control measure to reduce subsequent releases from wastes is to adopt the more protective low-POPs content level of 50 mg/kg for total PBDE (the sum of tetraBDE, pentaBDE, hexaBDE, heptaBDE, and decaBDE). IPEN indicates that, while more work is needed to improve inexpensive separation method to ensure repeatability and efficacy, current advances in flotation separation techniques have allowed the successful separation of brominated plastics from clean plastics in lower-income countries.

Table 9: Responses to the call for information on efficacy and efficiency of possible control measures for decaBDE (as of 12 December 2019)

Party	Comment
Canada	As of December 2016, the manufacture, use, sale, and import of decaBDE and products that contain decaBDE are prohibited in Canada by the *Prohibition of Certain Toxic Substances Regulations, 2012*, with limited exemptions. In October and December of 2018, the Government of Canada indicated the development of proposed amendments to the *Prohibition of Certain Toxic Substances Regulations, 2012*. These proposed amendments seek to further restrict manufactured items containing decaBDE by imposing a phase-out schedule for complete elimination of the manufactured item exemption. (Canada 2018a; Canada, 2018b).
Egypt	Capacity building and awareness programs
New Zealand	Use of decaBDE is only in parts for vehicles and aircraft as allowed by the specific exemption. As the average year of manufacture of vehicles in the New Zealand fleet, including the imported used vehicles, rises then the presence of parts containing decaBDE will decline.
Senegal	Limited capacity

5. Information on alternatives to decaBDE

56. Table 10 provides the responses received to the call for information. Canada noted that many commercially available alternatives such as other brominated FRs and halogen free FRs. The Risk Management Evaluation (UNEP/POPS/POPRC.11/10/Add.1) provides a comprehensive compilation of alternatives. It concludes: "Technically feasible alternatives appear to be available for all applications, however, service and replacement of legacy spare parts in articles already in use is not always practicable due to the need for testing of reconfigured parts often in original vehicles, which are no longer in mass production and often have not been for many years. This also applies for aircrafts currently in production under existing certificates."

57. IPEN noted that several strategies that could be adopted to enable a rapid transition to alternatives to decaBDE. For example, exemptions for parts in an older vehicle that can be substituted with parts that do not contain decaBDE could be revoked; new parts that do not contain decaBDE could be designed so that they fit older vehicles; priority could be given to interior parts to prevent release and subsequent human exposure; ensuring that only parts that require to be flame retardant are exempted; and restricting the use of decaBDE in parts to a small number that cannot be retrofitted with current production items, do not likely result in human or environmental exposure during production and/or use, and are used in a way that corresponds to the purported function of the substance. These same strategies could be applied to aircraft given that Boeing indicated to POPRC that it intended to remove decaBDE-containing materials from its specifications to assist production, maintenance, repair and overhaul activities avoid materials that contain this substance (UNEP/POPS/POPRC.12/INF/10).

58. Efficient and technically feasible alternatives to c-decaBDE as a FR in plastics (and synthetic rubber) are available on the market. The RME notes: "C-decaBDE phase-out could include FR substitution, resin/material substitution and product redesign as well as re-evaluation of fire-safety requirements. DBDPE may be the most likely drop-in substitute for c-decaBDE in most plastics, but other alternatives or non-chemical techniques may offer a more sustainable long-term alternative to c-decaBDE than DBDPE (UNEP/POPS/POPRC.11/10/Add.1)."

59. While replacing c-decaBDE use in textiles is not as straight forward, a number of affordable options are available. They include brominated additive FRs such as DBDPE, and the use of alternative techniques or inherent flame-resistant materials – alternative fibres, inherently fire-resistant fibres, barrier layers, and nonwovens, for example (UNEP/POPS/POPRC.11/10/Add.1).

60. One observer, IPEN, identified manufacturers and suppliers of Dechlorane Plus, a possible substitute which is currently being evaluated by POPRC: Mainchem (China), Haihang Industry Co (China), Amoy Chemical (China), Tianfu Chemical (China), J&K Scientific (China), Chemsky (China), HangZhou Yuhao (China), Micxy Chemical (China), and OxyChem (USA). IPEN also referred to Shanghai Xusen Non-Halogen Smoke Suppressing Fire Retardants Co. Ltd that manufactures halogen-free phosphorous- and nitrogen-based FRs.

61. More detailed information on alternatives can be found in the Annex and in the Risk Management Evaluation (UNEP/POPS/POPRC.11/10/Add.1).

Table 10: Responses to the call for information on the availability, suitability and implementation of alternatives to decaBDE (as of 12 December 2019)

Party	Comment
Belarus	Decabromodiphenyl ethane (decaBDPE) will be used.
Canada	Many alternatives to decaBDE exist and are commercially available. While PBDEs have been used for a wide array of applications, a variety of different alternatives are being used as replacements such as other brominated flame retardants and halogen free flame retardants (Canada, 2018b) A move away from decaBDE towards alternative flame retardants and, in certain cases, flame retardant barriers in products, in lieu of chemicals, means that many of the applications no longer use decaBDE, especially in view of the phase-out in the US and the broad controls in place and proposed in other jurisdictions.
Egypt	The international factories use alternatives to decabromodiphenyl ether In process to get project for New POPs Management
Monaco	Not applicable
New Zealand	With time, older vehicles will be replaced by newer models which do not contain decaBDE in parts.
Romania	Not applicable
Senegal	Not concerned

6. Information on the status of control and monitoring capacity for decaBDE

62. Six countries provided a response on the status of control and monitoring capacity for decaBDE (see Table 11). Under the Chemical Management Program (CMP) Canada has several environmental monitoring programs to monitor substances of concern in air, water, sediment and biota. DecaBDE has been measured in air, fish (low to no detection), sediment, municipal wastewater, landfill leachate and gull eggs. Monitoring of decaBDE and other PBDEs in air, sediments, municipal wastewater and gull eggs, is conducted on a routine basis. DecaBDE is also measured in human populations in the Canadian Health Measures Survey, the Maternal Infant Research on Environmental

Chemicals (MIREC) cohort and in the Canadian Arctic, through the Northern Contaminants Programme. Egypt is sending letters to customs officials to compile information on imported quantities of decaBDE. New Zealand is not actively monitoring, and Senegal has limited capacity to undertake control and monitoring. Monaco and Romania responded, "not applicable".

63. Air concentrations for various FRs, including PBDEs, were measured as part of the Global Atmospheric Passive Sampling (GAPS) Network programme. Although a trend towards increasing or decreasing atmospheric concentrations of PBDEs was observed at some sites, overall, atmospheric levels of PBDEs in 2014 were similar to those measured in 2005. BDE-209 was detected in 16% of samples at concentrations ranging from <0.8 to 52 pg/m^3. North American sites had higher levels overall, whereas, they were below the detection limits at European sites. This difference is likely due to the different use pattern of FR between the two continents. While the highest concentrations were measured at Sonora (Mexico) and Darwin (Australia), it is possible that the samplers were collecting PBDE from the buildings ventilation system meaning these samples may not represent ambient conditions (Rauert et al., 2018).

64. Some information is available on the presence of decaBDE in environmental media in Denmark. In 2015, Denmark analyzed municipal wastewater effluent from ten different wastewater treatment plants. All samples were below the method detection limit for decaBDE of 0.01 μg/l. A 2003 study of sewage sludge estimated that sewage sludge from a Danish municipal wastewater treatment plant at 258 μg decaBDE/kg dw. The most commonly used PBDEs, including decaBDE have been found in sediments, mussels, and fish. Monitoring in three fish species at seven locations found levels of PBDE in fish tissue (muscle) to be between 16 and 37 times above the Environmental Assessment Criteria. In 2011, the European Food Safety Authority estimated the average dietary exposure to decaBDE in Denmark to be between 0.62 and 1.86 ng/kg bw/d (Denmark, 2018).

65. In a study in Australia, BDE-209 was found in sample of biosolids. Mean concentrations at the different plants ranged from 67 to 1340 ng/g biosolids, with an average of about 500 ng/g. It was further estimated that 167 kg decaBDE is accumulated in biosolids in Australia per year. Given that 59% of biosolids in Australia are applied to agricultural land, approximately 99 kg of decaBDE are released to the environment this way (Australia, 2019). See Table 12 for a summary of environmental concentrations of decaBDE in Australia.

Table 11: Responses to the call for information on the status of control and monitoring capacity for decaBDE (as of 12 December 2019)

Party	Comment
Canada	Canada has a series of environmental monitoring programs to monitor substances of concern in air, water, sediment and biota. These programs have been integrated and augmented under the Chemical Management Program (CMP) to provide a fully national, multi-media program capable of meeting the Government of Canada's existing monitoring commitments (such as commitments under the Great Lakes Water Quality Agreement). These programs also serve to respond to newer emerging chemicals of concern. The CMP Environmental Monitoring and Surveillance Program includes the measurement of specific chemicals in outdoor air, water (lakes, rivers), sediments, aquatic biota and birds' eggs across Canada. In addition, since many of the emerging chemicals of concern are found in products which routinely end up in wastewater. Monitoring for this media has been initiated across Canada. The wastewater program aims to characterize trends of priority compounds in wastewater (effluents and biosolids) and assess the effectiveness of treatment systems for removing these substances before release to the environment. This information can be found in the most recent annual report published under the *Canadian Environmental Protection Act* (Canada, 2019a) Under the CMP Monitoring and Surveillance Program (Canada, 2012), decaBDE was measured in air, fish (low to no detection), sediment, municipal wastewater, landfill leachate and gull eggs. Monitoring of decaBDE and other PBDEs in air, sediments, municipal wastewater and gull eggs, is conducted on a routine basis, but not necessarily annually. DecaBDE is also measured in human populations in Canada. In the Canadian Health Measures Survey (Canada, 2017), PBDEs, including decaBDE, were measured in Cycle one of the survey (2007-2009). They will continue to be measured in future cycles. PBDEs have also been measured in the Maternal Infant Research on Environmental Chemicals (MIREC, 2019) cohort. Finally, PBDEs are also being measured in human populations in the Canadian Arctic, through the Northern Contaminants Program (refer to Canada, 2019c).
Egypt	Sending letters to customs with full data on decabromodiphenyl ether and HS code to identify the quantities imported during 2018-2019.
Monaco	Not applicable

New Zealand	No active monitoring is carried out, but as the average date of manufacture of vehicles rises then the presence of parts containing decaBDE will decrease
Romania	Not applicable
Senegal	Limited capacity

Table 12: Summary of measured environmental concentrations of BDE-209 in Australia (Australia, 2019)

Location	Matrix	Value	Reference
Brisbane (automotive shredding and recycling facility)	air	510 pg/m^3	Hearn et al., 2012
Melbourne (electronics recycling facility)	soil	13.1 mg/kg	McGrath et al., 2016
Melbourne (landfill)	soil	0.77 mg/kg	McGrath et al., 2016
Australia-wide	biosolids	0.07 – 1.34 mg/kg	Gallen et al., 2016
Parramatta river, Sydney	sediment	32.5 µg/kg	Toms et al. 2006
Port Phillip Bay, Melbourne	sediment	35.6 µg/kg	Toms et al. 2006
Port Jackson West, Sydney	sediment	22.5 µg/kg	Toms et al. 2006
Parramatta river, Sydney	sediment	45 µg/kg	Roach et al., 2008
Homebush bay, Sydney	*Haliaeetus leucogaster* (white-bellied sea eagle)	60 µg/kg	Manning et al., 2008
Urban Sydney and Brisbane	*Threskornis molucca* (white ibis) eggs	270 µg/kg lipid weight (mean) 550 µg/kg lipid weight (max)	Ridoutt and Kingsford, 2011
Peri-urban Sydney and Brisbane	*Threskornis molucca* (white ibis) eggs	100 µg/kg lipid weight (mean)	Ridoutt and Kingsford, 2011
Inland Australia	*Threskornis molucca* (white ibis) eggs	30 µg/kg lipid weight (mean) 80 µg/kg lipid weight (max)	Ridoutt and Kingsford, 2011

7. Information on the national or regional control actions taken for decaBDE

66. Table 13 provides the information on control actions in the responses received to the call for information. Canada indicated that the manufacture and use of decaBDE was first regulated in Canada in 2008. As of 2016, the *Regulations Amending the Prohibition of Certain Toxic Substances Regulations, 2012* prohibits the manufacture, use, sale and import of decaBDE, and products containing decaBDE, with a few exemptions. The government of Canada is proposing to further restrict the manufacture, use, sale, offer for sale and import of certain toxic substances including decaBDE. New Zealand indicated that decaBDE is listed as a persistent organic pollutant under the Hazardous Substances and New Organisms Act; no decaBDE can be manufactured or imported other than in parts as allowed for under the specific exemptions listed in the Stockholm Convention (refer also to Table 1, specific exemptions, and Table 3, articles in use, above). The responses received from the other Parties did not provide information on control measures. EU regulations would apply in Monaco and Romania.

67. The use of decaBDE in EEE within the scope of the Restriction of Hazardous Substances (RoHS) Directive ceased in the EU (including Denmark) in 2008. DecaBDE is listed in Annex XVII of the REACH Regulation (EU Regulation 2017/227 of 10/02/2017). With few exceptions (mainly use in aircraft), the manufacture or placing on the market of the substance is thereby banned effective 2 March 2019 in Denmark as a substance on its own, in another substance, as a constituent, as a mixture or in an article in concentrations exceeding 0.1% by weight. However, decaBDE may be present in recycled plastics into the future (Denmark, 2018). In 2019, the EU amended its

Ecodesign regulations to prohibit the use of halogenated flame retardants in the enclosure and stand of electronic displays effective 1 March 2021 (EU, 2019).

68. Norway has implemented the European WEEE Directive, the RoHS Directive which restricts the use of PBDEs, including c-decaBDE, in electronic products to 0.1% (1,000 mg/kg), and the European ELV Directive which promotes recycling. In ELV waste, the removal of large plastic components if these materials are not segregated in the subsequent shredding process is required. Waste containing c-decaBDE at or above 0.25% (2,500 mg/kg) must be handled as hazardous waste. The Norwegian Waste Regulation requires plastics with brominated flame retardants in e-waste to be separated as a first part of the treatment process unless an alternative mechanical, chemical or metallurgical process is demonstrated to equally environmentally sound (UNEP/CHW.13/INF/14).

69. In its NIP, Spain refers to the Delegated Directive (EU) 2016/585, which allows an exemption for PBDEs in spare parts recovered from and used for the repair or refurbishment of medical devices or electron microscopes, provided that the reuse takes place in auditable closed-loop business-to-business return systems and that each reuse of parts is notified to the customer (Spain, 2019). This exemption expires on 21 July 2021 for the use in medical devices other than in vitro diagnostic medical devices; on 21 July 2023 for the use in in vitro diagnostic medical devices; and on 21 July 2024 for the use in electron microscopes and their accessories.

70. All e-waste in New Zealand is considered hazardous waste unless verified otherwise. This includes e-waste containing brominated FR. If a product contains a brominated FR likely to be a POP listed under the Convention, then it cannot be recycled or exported for recycling. An export permit will only be issued if the waste material is to be processed in an environmentally sound manner (New Zealand, 2018).

71. In India, the E-Waste (Management) Rules, 2016 restrict the content of PBDE in EEE, including c-decaBDE, in EEE to 0.1% (1,000 mg/kg) (UNEP/CHW.13/INF/14). Facilities in Japan are required to report the volume of c-decaBDE transferred and disposed of on an annual basis. Part of the waste containing articles with c-decaBDE is incinerated; the rest is recycled or disposed of in landfill (UNEP/CHW.13/INF/14).

72. On 28 September 2017 the U.S. Consumer Product Safety Commission published a guidance document for manufacturers, importers, distributors, retailers, and consumers of certain consumer products that may contain organohalogen flame retardants (OFRs) in an additive form. "To protect consumers and children from the potential toxic effects of exposure to these chemicals, the Commission recommends that manufacturers of children's products, upholstered furniture sold for use in residences, mattresses (and mattress pads), and plastic casings surrounding electronics refrain from intentionally adding nonpolymeric, organohalogen flame retardants (''OFRs'') to their products. Further, the Commission recommends that, before purchasing such products for resale, importers, distributors, and retailers obtain assurances from manufacturers that such products do not contain OFRs. Finally, the Commission recommends that consumers, especially those who are pregnant or with young children, inquire and obtain assurances from retailers that such products do not contain OFRs" (CPSC 2017).

Table 13: Responses to the call for information on the national or regional control actions taken for decaBDE (as of 12 December 2019)

Party	Comments
Canada	In July 2008, the Government of Canada published the *Polybrominated Diphenyl Ethers Regulations* (PBDE Regulations) to protect Canada's environment from the risks associated with PBDEs by preventing their manufacture and restricting their use in Canada, thereby minimizing their release into the environment. In October 2016, *the Regulations Amending the Prohibition of Certain Toxic Substances Regulations, 2012* (Prohibition Regulations) were published in the Canada Gazette, Part II: Vol. 150, No. 20 - October 5, 2016 and came into force in December 2016 (Canada, 2016). The PBDE Regulations were repealed when these amendments came into force. The expanded scope of the Prohibition Regulations on PBDEs covers all PBDE substances ($4 \leq n \geq 10$). These regulations prohibit the manufacture, use, sale and import of decaBDE, and products containing decaBDE, with a limited number of exemptions. In October 2018, a notice of intent was published in the Canada Gazette, Part I: Vol. 152, No. 41 – October 13, 2018 indicating that the Department of the Environment and the Department of Health were initiating the development of additional amendments to the *Prohibition of Certain Toxic Substances Regulations, 2012* (Canada, 2018a). These amendments would seek to further restrict the manufacture, use, sale, offer for sale and import of certain toxic substances, including PBDEs. In December 2018, Environment and Climate Change Canada and Health Canada (Canada, 2018b) published a consultation document on a proposed regulatory approach to amend the *Prohibition of Certain Toxic Substances Regulations, 2012* for PBDEs as well as other

	substances (perfluorooctane sulfonate [PFOS], perfluorooctanoic acid [PFOA], long-chain perfluorocarboxylic acids [LC-PFCAs], hexabromocyclododecane [HBCD], dechlorane plus [DP], and decabromodiphenyl ethane [DBDPE]).
Egypt	None
Monaco	Not applicable
New Zealand	DecaBDE is listed as a persistent organic pollutant under the Hazardous Substances and New Organisms Act in New Zealand. No decaBDE can be manufactured or imported other than in parts as allowed for under the specific exemptions listed in the Convention.
Romania	Not applicable
Senegal	None

8. Information on the progress made in building the capacity of countries to transfer safely to reliance on alternatives to decaBDE

73. Six Parties included a response to the progress made in building the capacity of countries to transfer to the use of alternatives to decaBDE (see Table 14). Egypt indicated that training had taken place for industrial facilities and government staff. Canada indicated there was no information available. Monaco, Qatar and Romania responded, "not applicable" and Senegal noted that this was not of concern.

Table 14: Responses to the call for information on building the capacity of countries to transfer safely to reliance on alternatives to decaBDE (as of 12 December 2019)

Party	Response
Canada	No information available
Egypt	Trained 200 workers of industrial facilities in the new cities Trained 60 staff of Regional Branches Offices (RBOs) of the Ministry of Environment
Monaco	Not applicable
Qatar	Not applicable
Romania	Not applicable
Senegal	Not concerned

9. Analysis of the information and recommendations

74. For most Parties, the listing of decaBDE came into effect on 18 December 2018. The specific exemptions for production and use of decaBDE are time-limited, and generally expire 5 years after the date of entry into force, unless an extension is requested by Parties and granted by the COP or otherwise specified in decision SC-8/13. As of 3 February 2020, five parties had registered for specific exemptions. The European Union and Switzerland have registered for both production and use as outlined in Annex A. Brazil, Iran and New Zealand have registered exemptions for certain uses with expiry dates that conform in Decision SC-8/10. No Party has registered an exemption for polyurethane foam for building insulation.

75. Limited information has been provided through the call for information on the justification for the continued need for specific exemptions for decaBDE. In decision SC-8/13 on the review of information related to specific exemptions for decaBDE the COP invited each Party listed in the register of specific exemptions to report to the Secretariat, by December 2019, justifying its need for the registration of that exemption. Nine responses were received, three of which were from Parties that have registered for specific exemptions for decaBDE (Germany and Romania are members of the European Union; and New Zealand). The other six Parties indicate exemptions were either not needed or not applicable. While Egypt indicated that it did not need an exemption, it noted that decaBDE is used in textiles.

76. Only a few Parties have their NIP updated for decaBDE. Of those, one indicated that it would not need an exemption and four indicated that they have yet to determine if specific exemptions would be needed.

77. Limited information was received from the call for information on the extent of current use of decaBDE. DecaBDE has many applications with plastic manufacturing accounting for most of the use. It is also used in textiles. The use of decaBDE is severely restricted in several countries including Canada and members of the European Union.

In Australia, about 250 t of decaBDE were imported in 2017 for use in plastics, rubber, textiles, and building applications. An industry forecast projects a growth in the market for decaBDE of over 40% between 2018 and 2025.[7]

78. While only two Parties have submitted notifications of articles in use to the Secretariat, several Parties indicate that decaBDE enters into their markets in products and articles. Analysis of articles on the market and in waste indicate that decaBDE can frequently be found in products made of recycled plastics. In EEE, concentrations range from 10 to 15%. High levels of decaBDE and other brominated FR in plastics is reported to be a barrier to recycling.

79. In light of the available information, possible course of action includes:

(g) Continue to evaluate the need for exemptions and prepare a report for consideration at the eleventh meeting of the COP (in 2023): Overall, there is currently limited information available to inform the review of decaBDE exemptions, therefore another review cycle may be needed. In addition, of the 11 NIPs reviewed, four indicated that an assessment of the need for an exemption had not been undertaken. This would give more time for Parties to seek guidance (as needed), collect more national information, assess their need for exemptions, and register for these in compliance with the Convention obligations. This would ensure that COP has the necessary information to make an informed decision, in the event that it is asked for an extension to the current time-limitation.

(h) Review exemptions for which no Party has registered and evaluate the need for maintaining such exemptions and prepare a report for consideration at the eleventh meeting of the COP (in 2023): Identifying exemptions for which no Party has indicated a need would allow to remove some exemptions which may no longer be needed.

(i) Encourage Parties to register for the needed exemptions and provide notifications of article in use in compliance with the requirements under the Convention: There is evidence that decaBDE is present in a wide range of articles, yet only two Parties have provided a notification for article in use. In addition, a Party has not registered for an exemption even though it has indicated current use.

(j) Invites Parties that have registered for specific exemptions to provide adequate information on the justification for the continued need for such exemptions to enable the Conference of Parties in undertaking the review of entries in the register of specific exemptions for decaBDE.

(k) Encourage Parties to promote the transition to alternatives: The Risk Management Evaluation (UNEP/POPS/POPRC.11/10/Add.1) concluded that technically feasible alternatives appear to be available for all applications, though for service and replacement of legacy spare parts in articles already in use in vehicles and aircraft is not always practicable. Presence of decaBDE in articles that are recycled can also result in contamination of recycled materials. Parties could be encouraged to:

- (i) Promote of the use of known alternatives to decaBDE taking into consideration POPs characteristics or other hazardous properties of these alternatives, , with the recognition that the POPRC has not assessed whether these alternatives meet the Convention's Annex D screening criteria;
- (ii) Continue the identification of suitable alternative substances/processes and sharing that information with other Parties via the Secretariat which could then be included in guidance documents on alternatives (UNEP/POPS/COP.9/INF/20); and use of the preliminary draft guidance on preparing inventories (UNEP/POPS/COP.9/INF/18 and UNEP/POPS/COP.9/INF/19/Add.1) to collect national information.

(l) Encourage Parties to take measures to ensure the environmentally sound the management of wastes containing decaBDE: There continues to be widespread presence of decaBDE in articles in use, including articles made from recycled plastics. The presence of decaBDE in plastics is reported to be a constraint to the recycling of plastic products at end-of-life, release of POPs into the environment if they are not disposed of in an environmentally sound manner and can result in the presence of decaBDE in recycled plastics. The continued production and use of products containing decaBDE implies that the latter will be present in the waste stream for a considerable duration.

[7] https://www.businesswire.com/news/home/20190625005422/en/Decabromodiphenyl-Ether-Market-worth-USD-430-Million (Accessed 2019-12-31).

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Appendix 1: Alternatives to decabromodiphenyl ether (commercial mixture, c-decaBDE)

1. The following information is primarily extracted from the Risk Management Evaluation (UNEP/POPS/POPRC.11/10/Add.1).

2. A number of non-POP chemical alternatives are already on the market for the substitution of c-decaBDE in plastics and textiles. Furthermore, non-chemical alternatives and technical solutions such as non-flammable materials and physical barriers, respectively, are also available.

1. Uses of decaBDE

3. C-decaBDE is a synthetic substance with no known natural occurrence that is used as a flame retardant (FR) in many applications worldwide, primarily in plastic polymers and textiles. Although fire regulations are mandatory for the market, there are no fire regulations that require the use of certain FRs in order to comply with these standards or regulations. Hence, it is up to the manufacturers to decide which technique to use. Alternatives to C-decaBDE can include FR substitution, resin/material substitution and product redesign as well as re-evaluation of fire-safety requirements.

4. The plastics industry is by far the major user of FR and the largest quantities of FR are supplied to raw-material manufacturers. The amount of c-decaBDE used in plastics and textiles globally varies but up to 90% of c-decaBDE ends up in plastic and electronics while the remaining ends up in coated textiles, upholstered furniture and mattresses. EEE applications include equipment casings, wires and cables, and small electrical components. Other identified uses of c-decaBDE flame-retarded plastics are in buildings, construction materials, in storage and distribution products such as plastic pallets, in the transportation sector (cars, airplanes, trains and ships).

5. In its update to its national implementation plan Denmark (2018) identified the following applications in polymers, with a typical concentration of 10-15% decaBDE.

(a) Polyolefin polymers, e.g. polyethylene, polypropylene, polyphenylene ether and ethylene vinyl acetate, used for power cables, insulation of wires, conduits, stadium seating, electrical connectors and boxes, heat shrinkable material, shipping pallets and roofing membranes;

(b) Styrenics, e.g. high impact polystyrene, acrylonitrile butadiene styrene and polyphenylene oxide/polystyrene;

(c) A number of engineering plastics, e.g. polyesters, polyamides, polyimides, polycarbonate and melamine;

(d) Thermosets such as unsaturated polystyrene;

(e) Elastomers such as Ethylene propylene diene monomers rubber, styrene-butadiene rubber, thermoplastics polyurethane and ethylene vinyl acetate;

(f) Various water-based emulsions and coatings.

6. DecaBDE is useful for treating some of the most popular upholstery materials: mixtures of polyester, acrylic and viscose fibres. Less of it is used in window blinds, curtains, tents, indoor fabrics of cars. DecaBDE is not used in clothing, bedding or protective clothing where there is risk of prolonged contact with skin (Denmark, 2018).

7. The aviation industry still uses c-decaBDE in electrical wiring and cables, interior components, and EEE in older airplanes and spacecraft. C-decaBDE is expected to be present in plastics and textiles in several waste streams such as "end-of-life vehicles" (ELV), e-waste, textile- and mixed waste.

8. Technically feasible alternatives appear to be available for all applications, however, service and replacement of legacy spare parts in articles already in use is not always practicable due to the need for testing of reconfigured parts often in original vehicles, which are no longer in mass production and often have not been for many years. This also applies for aircrafts currently in production under existing certificates.

2. Alternatives available for use in plastics

9. For plastics in EEE, substitution strategies range from exchange of the resin system and FR, to complete redesigns of the product itself. According to the EU restriction proposal, which assessed different alternatives to c-decaBDE. Eight possible alternative chemicals appear to be possible substitutes for c-decaBDE in plastic polymers:

(a) Decabromodiphenyl ethane (DBDPE);

(b) Bisphenol A bis(diphenyl phosphate) (BDP/BAPP);

(c) Resorcinol bis(diphenylphosphate) (RDP);

(d) Ethylene bis(tetrabromophthalimide) (EBTBP);

(e) Magnesium hydroxide (MDH);

(f) Triphenyl phosphate (TPP);

(g) Aluminium trihydroxide (ATH);

(h) Red phosphorous.

3. Alternatives available for use in textiles

10. C-decaBDE has traditionally been applied to textiles used in transportation (public transit buses, trains, aviation and ships), draperies for use in public occupational spaces, furniture of high-risk occupational areas such as nursing homes, hospitals, prison and hotels, and military for tarps, tents and protective clothing, but are not used in consumer clothing. C-decaBDE is used as a back-coating in combination with antimony oxide (ATO) as a synergist. According to U.S. furniture industry sources in 99% of cases, chemical FRs will not be needed to meet pending national standards for residential upholstery. However, FRs are still widely used in furniture.

11. There is no single replacement for c-decaBDE for textiles applications, but viable approaches exist. A number of affordable options are available to replace c-decaBDE uses in furniture, mattresses, draperies and other textile applications. Substitution options for textiles range from brominated additive FRs such as DBDPE, to alternative techniques and inherent flame-resistant materials; DBDPE [T4] would be the preferred alternative to c-decaBDE in textiles.

12. The most common FR for polyester is polyethylene terephthalate with built-in phosphorus on the polyester backbone and is considered a good substitute for the c-decaBDE/antimony flame retardant (FR) in clothing and draperies.

13. The following seven substances were identified as the most likely chemical alternatives to the use of c-decaBDE in textiles:

(a) Aluminum trihydroxide (ATH);

(b) Magnesium hydroxide (MDH);

(c) Tris(1,3-dichloro-2-propyl) phosphate (TDCPP);

(d) Ethylene bis(tetrabromophthalimide) (EBTBP);

(e) 2,2'-oxybis[5,5-dimethyl-1,3,2-dioxaphosphorinane] 2,2'-disulphide;

(f) Tetrabromobisphenol A bis (2,3-dibromopropyl ether) (TBBPA) (only in polymer applications);

(g) Red phosphorous;

(h) Decabromodiphenyl ethane (DBDPE).

Natural or protein fibres

14. There are several chemical non-halogen c-decaBDE substitutes available for natural cellulose or protein fibres such as cotton, wool, rayon (viscose, modal and lyocell), and linen. They include:

(a) Ammonium polyphosphates;

(b) Dimethylphosphono (N-methylol) propionamide;

(c) Phosphonic acids such as (3-{[hydroxymethyl]amino}-3-oxopropyl)-dimethyl ester;

(d) Tetrakis (hydroxymethyl) phosphonium urea ammonium salt.

4. Alternatives available for other uses

15. C-decaBDE is used in sealants, adhesives, architectural foam, and coatings as well as in some applications in buildings and construction. C-decaBDE is used in wall and roof panels, which are typically made from unsaturated polyester (UPE) glass composites; floor tiles; and commercial grade carpeting. C-decaBDE is also used in insulation materials, roofing materials such as membranes and films for use under roofs to protect building areas. C-decaBDE can also be found in ducting elements such as the duct covering or insulation. The following six chemicals have been identified as alternative substances for these applications:

(a) Magnesium hydroxide (MDH);

(b) Aluminum trihydroxide (ATH);

(c) Ethylene bis(tetrabromophtalimide) (EBTBP);

(d) Substituted amine phosphate mixture (P/N intumescent systems);

(e) Red phosphorous;

(f) Decabromodiphenyl ethane (DBDPE).

5. Alternative techniques

16. Alternative techniques to improve fire safety exist such as inherent flame-resistant material, use of different technical solutions, i.e. barriers or complete redesign of the product.

Alternative materials for decaBDE use in plastics

17. Metal or inherently flame-resistant plastic can be used as alternative materials; intumescent systems, nanocomposites, expandable graphite, smoke suppressants, polymer blends, and layering are other options. Halogenated polymers such as PVC have FR properties because they release halogen radicals during combustion; however, like brominated FRs, PVC may form dioxins and acids upon combustion and are therefore not a preferred alternative FR material.

18. The following are polymer materials that are inherently flame-retardant and which might be considered as a substitute to c-decaBDE-based polymers such as poly(butylene terephthalate) (PBTE) or polyamide/ nylon (PA):

(a) Halogen-free polyketone (this is considerably more costly than PBTE and PA);

(b) High performance thermoplastics such as polysulphone, polyaryletherketone (PAEK) or polyethersulphone (PES).

19. Polymers that char such as polyimides, polyaramides, liquid crystal polyesters, polyphenylene sulphide, polyarylenes and many thermosets also tend to have a greater resistance to fire. Where the base polymer has FR properties, depending on the end use, a sufficient level of fire performance may be achieved without the need for chemical FRs or much lower loadings may be required.

20. It may be necessary to change product designs to adopt these alternative materials and their implementation would require higher level of research and development activities than the substitution of c-decaBDE with a FR drop-in chemical replacement.

Redesign

21. Redesign has successfully replaced c-decaBDE in several EEE applications: for example, separating high-voltage components that need greater ignition protection from low-voltage components; reducing operating voltage requirements and therefore reducing the need for flame-retarded enclosure materials; removing sources of ignition; reducing operative voltage; removing the power supply from the product.

Alternative techniques to replace the use of decaBDE in textiles

22. Products can be redesigned to incorporate non-flammable materials or barrier technologies. Two approaches are suitable: 1) use of cover fabrics made from materials that are inherently fire resistant, 2) use of fire-resistant barriers between the cover fabric and the flammable cushioning foam.

23. A number of synthetic fibres are inherently flame resistant, including aramid, viscose, novoloid, polyamides, and melamine. Inherently flame resistant fibres like polyhaloalkenes contain halogens such as polyvinyl chloride and vinyl bromide, while others are halogen free, including polyaramides and melamine fibres. Other inherently flame-retarded materials include rayon with a phosphorus additive, polyester fibres, and aramids. In addition, some natural materials like leather and wool have inherently fire-resistant properties. Blending natural and synthetic fibres is another approach: 'poly-cotton'; cotton-nylon; or cotton or polyester blended with melamine.

24. In furniture, barriers can be used between the surface fabric and the interior foam core. These can be made from inherently flame-retarded fibres such as wool, para aramids, melamines, modacrylics, or glass fibre. In addition, many of these fibres are made from non-halogen materials. Plastic films have also been used as barriers, especially films made of inherently flame-resistant plastics such as neoprene (polychloroprene). Cotton-batting materials treated with boric acid have also been used; however, there are some toxicological concerns with boric acid.

25. Intumescent systems: Intumescence is the formation of a foamed char, which acts as heat insulation. Intumescent systems include use of expandable graphite impregnated foams, surface treatments and barrier technologies of polymer materials. Intumescent systems may not be applicable to the same sets of textiles as brominated FR-based back-coatings.

26. Flammability standards: Fire toxicity is the largest cause of death and injury in fires but is usually not taken into account. An overall reduction of flame-retarded materials may therefore lead to a smaller risk of health problems for the general public and fire fighters, if fire safety can be achieved by other means. For example, Californian furniture flammability standards have been changed such that future use of FRs can be excluded.

27. Reduced ignition propensity (RIP): As cigarettes are a common cause of fires. Requiring that all cigarettes sold have reduced ignition propensity is an effective method to reduce fire risk.

28. For further information, please refer to UNEP/POPS/POPRC.5/10/Add.1 – General guidance on considerations related to alternatives and substitutes for listed persistent organic pollutants and candidate chemicals.

Appendix 2: Overview of identified uses reported by decaBDE registrants under the REACH regulation

Table: Overview of identified uses reported by decaBDE registrants under the REACH regulation identifying the related industry sector (building and construction (BC), textiles and furniture (TF), transport (T) and electric and electronic equipment (EE)) and estimated life cycle stages

(m: manufacture, f: formulation/compounding, c: conversion, u: article use, w: waste)

Source: Norway, 2015.

No.	Identified uses	Industry sector				Life cycle stage				
		BC	TF	T	EE	m	f	c	u	w
1	Adhesive and sealant	X	X	X	(X)		X		X	
2	Coatings and inks formulation***	X	X	X	X		X			
3	Coating used in textile back coating		X				X	X		
4	Coating and inks application (consumer, industrial and professional use)***	X	X	X	X			X	X	
5	Coating used in textiles		X				X	X		
6	Coatings – industrial application of coatings	X	X	X	X			X		
7	Converting	(X)	(X)	(X)	(X)			X		
8	Filled dispersion used in transportation			X				X	X	
9	Filled dispersion used in construction***	X						X	X	
10	Foam production for construction***	X					X	X	X	
11	Formulation of flame retardant preparation	X	X	X	X		X			
12	Formulation coating preparation	X	X	X	X		X			
13	Formulation polyester and S102E* – liquid filled dispersion	X	X	X	X		X			
14	Industrial composites manufacturing	X					X	X		
15	Manufacturing of formulated resins (gel coats, etc.)	X	X	X	X		X	X		
16	Manufacturing of vinyl ester resins***	X	X	X	X		X			
17	Professional application of coatings***	X	X	X	X			X	X	
18	Professional composites manufacturing***	X						X	X	
19	Recycling	(X)	(X)	(X)	(X)					X
20	Thermoplastic production (master batch and compound)	X	X	X	X		X			
21	Thermoplastic used in automotive			X			X	X	X	
22	Thermoplastic used in construction	X					X	X	X	
23	Transformation**, ***	(X)	(X)	(X)	(X)			X		
24	Wire and cable used in automotive			X			X	X	X	
25	Wood and plastic composite***	X					X	X	X	

Note: It is assumed that flame retardant formulations, coatings, resins, polyesters and thermoplastics are applied in all indicated sectors. It is assumed that composites / composite materials are at least used in the building and construction sector. For the identified uses converting, recycling and transformation it is estimated that these processes take place in all indicated sectors.

* S102E probably refers to a commercial decaBDE mixture; the use most likely describes the preparation of the formulation, which is applied as back coating of textiles.

** The term "transformation" most likely refers to the production of (semi-finished or finished) plastic articles.

*** Life-cycle stages as reported by RPA (2014) could not be consolidated through consultations.

Appendix 3: Identification of brominated flame retardants in consumer articles

Concentrations of selected flame retardants in articles measured by X-ray fluorescence (XRF) (Gallen, et al. 2014)

Product type	No of XRF measurements for product type	% of total no of XRF measurements (n = 1714)	% of XRF measurements[a] in which bromine was detected (n)	% of XRF measurements[a] > 1000 ppm (n)	% of XRF measurements[a] > 10000 ppm (n)	Maximum XRF measurement (ppm)
Baby accessories	11	1	18 (2)	0	0	430
Car accessories	125	7	38 (48)	4 (5)	0	3800
Car dashboard/surfaces	38	2	46 (18)	0	0	580
Child car seat	15	1	33 (5)	20 (3)	0	174
Electronic computer	133	7	40 (53)	8 (10)	3 (4)	189,029
Electronic consumer tool	44	3	43 (19)	2 (1)	0	1075
Electronic large household appliance	193	11	43 (83)	7 (14)	5 (9)	84,828
Electronic small household appliance	614	36	58 (355)	21 (128)	9 (54)	172,585
Electronic other	202	12	69 (139)	35 (70)	23 (46)	114,422
Electronic telephone	14	1	64 (9)	29 (4)	0	4040
Electronic television	82	5	87 (71)	68 (56)	62 (51)	124,868
Furniture other	5	0.3	100 (5)	60 (3)	40 (2)	106,323
Plastic other	138	8	37 (51)	5 (7)	3 (4)	61,239
Toy plastic	134	6	34 (27)	2 (8)	3	92,983
Total	1714		51 (882)	18 (310)	10 (173)	

[a] Total number of XRF measurements for product type.

Amount of selected flame retardants (ng/swipe) on articles measured by surface swipe (Gallen, et al. 2014)

Product type	No of wipes	BDE-209		Total PBDEs		Total HBCDDs		TBBPA	
		% detects (n)	Detects range	% detects (n)	Detects range	% detects (n)	Detects range	% detects (n)	Detects range
Electronic television	20	55 (11)	8.9–10,000	60 (12)	1.8–11,000	20 (4)	4.4–12	55 (11)	75–180,000
Electronic small household appliances	75	48 (36)	8–1900	61 (46)	0.8–2400	13 (10)	3.6–230	47 (35)	2.7–20,000
Electronic large household appliances	9	11 (1)	26	22 (2)	0.58–26	11 (1)	84	22 (2)	4.2–220
Electronic other	19	68 (13)	18–14,000	84 (16)	18–19,000	5 (1)	11	58 (11)	8.4–22,000
Toy plastic	3	33 (1)	13	33 (1)	21	0	..	33 (1)	20,000
Plastic other	5	60 (3)	48–13,000	60 (3)	48–14,000	20 (1)	48	67 (2)	3.9–2800
Baby accessories	3	33 (1)	25	33 (1)	25	0	..	0	..
Electronic computer	3	67 (2)	7.5–680	67 (2)	7.5–740	33 (1)	69	33 (1)	35
Total	137	50 (68)	8–14,000	61 (83)	0.8–19,000	13 (18)	3.6–230	47 (63)	2.7–180,000

[a] Results have been rounded to 2 significant figures.

Concentrations (ug/g) of selected flame retardants in articles measured by destructive testing (Gallen, et al. 2014)

Product type	No of samples	BDE-183		BDE-197		BDE-209		TBBPA	
		% detects (n)	Detects range	% detects (n)	Detects range	% detects (n)	Detects range	% detects (n)	Detects range
Electronic television	12	58 (7)	14–830	50 (6)	60–215	83 (10)	11–88,600	83 (10)	110–130,000
Electronic small household appliances	17	24 (4)	21–1780	24 (4)	18–750	41 (7)	44–5050	59 (10)	26–160,000
Electronic large household appliances	4	0	..	0	..	0	..	50 (2)	12–110
Electronic other	10	33 (3)	240–2470	33 (3)	100–1100	50 (5)	1080–18,000	70 (7)	59,000–164,000
Toy plastic	2	0	..	0	..	0	..	50 (2)	150–140,000
Plastic other	1	100 (1)	170	100 (1)	80	100 (1)	8800	100 (1)	2700
Electronic computer	2	50 (1)	16	50 (1)	14	50 (1)	1300	50 (1)	150
Total	48	33 (16)	14–2470	33 (15)	14–1100	50 (24)	11–88,600	68 (33)	12–164,000

Comparison of levels of selected flame retardants identified in articles as measured by XRF, surface wipe and destructive testing (Gallen et al, 2014)

Sample name	Product description	XRF measurement (ppm)	Surface wipe (ng per wipe)				Destructive testing (μg g⁻¹)			
			BDE-183	BDE-197	BDE-209	TBBPA	BDE183	BDE197	BDE209	TBBPA
1	Power adapter	68,435	n.d.	n.d.	13	20,124	n.d.	n.d.	n.d.	180,000
2	Power adapter	42,057	246	119	3423	22,417	245	100	8100	60,000
3	Power adapter	55,881	1934	805	14,200	16,879	2470	1120	18,000	68,500
4	Television	117,153	78	17	326	1526	275	140	74,000	3800
4[a]	Television	104,250	65	23	418	2481	260	150	70,000	3700
6	CD player	105,530	n.d.	n.d.	<3xbl	3583	n.d.	n.d.	n.d.	180,000
6[a]	CD player	105,530	n.d.	n.d.	<3xbl	3583	n.d.	n.d.	n.d.	153,000
8	Television	123,953	4.4	1.8	398	104	n.d.	n.d.	840	n.d.
9	Power adapter	34,822	n.d.	7.4	n.d.	26	n.d.	n.d.	n.d.	n.d.
10	Television	117,580	386	92	7582	863,197	270	140	83,000	3800
11	Television	117,318	345	162	4886	2575	210	115	85,000	2300
12	Power adapter	746	n.d.	n.d.	<3xbl	n.d.	n.d.	n.d.	n.d.	n.d.
13	Laminator	83,752	632	310	1928	30,342	1700	750	5050	70,000
14	Power adapter	84,767	1.0	0.56	881	n.d.	n.d.	n.d.	2700	70,200
15	Power adapter	86,833	4.5	2.0	31	<LOQ	n.d.	n.d.	1680	139,500
16	Plastic toy	44,606	n.d.	n.d.	10	20,129	n.d.	n.d.	n.d.	143,000
17	Deep fryer	103,353	n.d.	n.d.	1111	29	n.d.	n.d.	n.d.	n.d.
17[a]	Deep fryer	103,353	n.d.	n.d.	1111	35	n.d.	n.d.	n.d.	n.d.
19	Plastic toy	<LOD	n.d.	n.d.	<3xbl	<LOQ	n.d.	n.d.	n.d.	150
20	Power adapter	68,173	188	73	3868	n.d.	680	310	11,800	58,000
21	Tower Fan	3101	17	8	183	43	40	21	730	1110
22	Television	94,238	336	134	9973	4801	110	60	47,700	1520
23	Power adapter	83,988	n.d.	n.d.	16	n.d.	n.d.	n.d.	n.d.	184,000
24	Electric fan	19	n.d.	n.d.	<3xbl	<LOQ	n.d.	n.d.	n.d.	n.d.
25	Electric fan	2488	21	13	2361	819	23	13	800	780
25[a]	Electric fan	2488	21	13	2361	819	22	20	760	920
27[b]	High pressure cleaner	<LOD	-	–	–	–	n.d.	n.d.	n.d.	n.d.
28	Television	182,373	93	47	9984	966	430	235	88,600	2300
29	Power adapter	994	n.d.	n.d.	<3xbl	42	n.d.	n.d.	n.d.	n.d.
30	Deep fryer	58,015	n.d.	n.d.	40	6.5	n.d.	n.d.	770	28
31	Generator	48,068	n.d.	n.d.	n.d.	3.2	n.d.	n.d.	n.d.	110
32[b]	Generator	45,487	-	–	–	–	n.d.	n.d.	n.d.	100
33	Television	113,300	n.d.	n.d.	n.d.	n.d.	14	n.d.	720	110
34	Clothes dryer	<LOD	n.d.	n.d.	<3xbl	n.d.	n.d.	n.d.	n.d.	12
35	Christmas ornament	19,411	123	70	13,423	2613	170	80	8300	2700
36	High pressure cleaner	451	n.d.	<LOQ	140	n.d.	n.d.	n.d.	44	n.d.
37	Computer	<LOD	n.d.	n.d.	6.9	<LOQ	n.d.	n.d.	n.d.	n.d.
38	Iron	61,397	n.d.	n.d.	<3xbl	<LOQ	n.d.	n.d.	n.d.	26
39	Sandwich press	143,065	n.d.	n.d.	<3xbl	n.d.	n.d.	n.d.	n.d.	n.d.
40	Clothes dryer	<LOD	n.d.	n.d.	<3xbl	n.d.	n.d.	n.d.	n.d.	n.d.
41	CD player	850	n.d.	n.d.	<3xbl	1677	n.d.	n.d.	n.d.	820
42	Television	114,801	n.d.	n.d.	<3xbl	23,230	n.d.	n.d.	n.d.	139,000
42[a]	Television	114,801	n.d.	n.d.	<3xbl	23,230	n.d.	n.d.	n.d.	150,000
44	Vacuum cleaner	<LOD	n.d.	n.d.	11	n.d.	n.d.	n.d.	n.d.	29
45	Computer	2381	8.6	3.9	680	75	16	14	1320	150
46	Microwave	134,529	<LOQ	0.68	420	<LOQ	n.d.	n.d.	74	n.d.
47	Television	117,871	n.d.	n.d.	<3xbl	<LOQ	n.d.	n.d.	13	n.d.
48	Television	117,865	n.d.	n.d.	<3xbl	<LOQ	n.d.	n.d.	11	n.d.

n.d. = did not exceed the limit of detection

[a] Indicates replicate samples (for comparison purposes, the wipe results of one replicate are adopted for the other).

[b] Surface wipes were lost; <3xbl indicates that amounts did not exceed three times the blank amount.

Appendix 4: Concentrations of decaBDE in material, articles and waste

Table A4-1 Concentrations of decaBDE in articles made from recycled materials (Reproduced from Potrykus et al., 2019)

Country/ region	Product/product category	Product category	Concentration [mg/kg]	Evidence of other POP-BDEs	Reference
Austria	Toy gun	Toy	147 - 359	yes	[Straková et al. 2018a]
Austria	Fidget spinner	Toy	307	yes	[Straková et al. 2018a]
Austria	Hair clip	Hair accessory	132 - 458	yes	[Straková et al. 2018a]
Austria	Hair brush	Hair accessory	101	yes	[Straková et al. 2018a]
Belgium	Telescope	Toy	660	yes	[Straková et al. 2018a]
Belgium	Hair brush	Hair accessory	57 – 86	yes	[Straková et al. 2018a]
Belgium	Hair clip	Hair accessory	26	yes	[Straková et al. 2018a]
United Kingdom	Black plastic kitchen utensils	Kitchen utensil	< 0.0026 - 140		[Kuang et al. 2018]
Hungary, Canada, USA, Kyrgyzstan, Nepal and Thailand	Carpet paddings		1 - 166		[DiGangi et al. 2011]
Czech Republic, Slovakia	Combs and headdress	Hair accessory	0 - 195		[DiGangi et al. 2017]
Italy, Czech Republic, Germany	Different toys	Toy	210 – 9,225		[Guzzonato et al. 2017]
Czech Republic	Gun	Toy	511	yes	[Straková et al. 2018a]
Czech Republic	Kitchen set	Kitchen utensil	24	no	[Straková et al. 2018a]
Czech Republic	Pastry brush set	Kitchen utensil	24	yes	[Straková et al. 2018a]
Czech Republic	Knife	Kitchen utensil	9 - 195	yes	[Straková et al. 2018a]
Czech Republic	Fork	Kitchen utensil	144	yes	[Straková et al. 2018a]
Czech Republic	Gun	Toy	511	yes	[Straková et al. 2018a]
Czech Republic	Kitchen set	Kitchen utensil	24	no	[Straková et al. 2018a]
Czech Republic	Pastry brush set	Kitchen utensil	24	yes	[Straková et al. 2018a]
Czech Republic	Knife	Kitchen utensil	9 - 195	yes	[Straková et al. 2018a]
Czech Republic	Fork	Kitchen utensil	144	yes	[Straková et al. 2018a]
Czech Republic	Gun	Toy	511	yes	[Straková et al. 2018a]
Czech Republic	Kitchen set	Kitchen utensil	24	no	[Straková et al. 2018a]
Czech Republic	Pastry brush set	Kitchen utensil	24	yes	[Straková et al. 2018a]
Czech Republic	Knife	Kitchen utensil	9 - 195	yes	[Straková et al. 2018a]
Czech Republic	Fork	Kitchen utensil	144	yes	[Straková et al. 2018a]
Czech Republic	Gun	Toy	511	yes	[Straková et al. 2018a]
Czech Republic	Kitchen set	Kitchen utensil	24	no	[Straková et al. 2018a]
	Plastic polymers in WEEE/ELV	EEE/articles	0.2 - 590		[UBA Sub. 2018]
produced in Czech Republic	Plastic roofing (recycled PVC)		21.06		[IPEN & Arnika Sub. 2018a]
Denmark	Magic cube star	Toy	4	yes	[Straková et al. 2018a]

Country/ region	Product/product category	Product category	Concentration [mg/kg]	Evidence of other POP-BDEs	Reference
Denmark	Fidget cube	Toy	16	yes	[Straková et al. 2018a]
Denmark	Toy gun	Toy	3 – 33	yes	[Straková et al. 2018a]
Denmark	Diadem	Hair accessory	2	yes	[Straková et al. 2018a]
Denmark	Hairclip	Hair accessory	71	yes	[Straková et al. 2018a]
France	Toy gun	Toy	1,043	yes	[Straková et al. 2018a]
France	Musical mobile phone	Toy	21	yes	[Straková et al. 2018a]
France	Water gun	Toy	322	yes	[Straková et al. 2018a]
France	Diadem	Hair accessory	2 - 293	yes	[Straková et al. 2018a]
France	Hairclip	Hair accessory	718	yes	[Straková et al. 2018a]
Germany	Formula 1	Toy	33	yes	[Straková et al. 2018a]
Germany	Magic cube	Toy	25 – 442	yes	[Straková et al. 2018a]
Germany	Toy gun	Toy	247	yes	[Straková et al. 2018a]
Germany	Hair brush	Hair accessory	30 - 93	yes	[Straková et al. 2018a]
Germany	Comb	Hair accessory	17	yes	[Straková et al. 2018a]
Germany	Mini hair claws	Hair accessory	<LOQ		[Straková et al. 2018a]
Germany	Massage roller	Other	178	yes	[Straková et al. 2018a]
Germany	Waste bin	Other	165	yes	[Straková et al. 2018a]
Netherlands	Water gun	Toy	<LOQ		[Straková et al. 2018a]
Netherlands	Diadem	Hair accessory	20	yes	[Straková et al. 2018a]
Netherlands	Hair clip	Hair accessory	569	yes	[Straková et al. 2018a]
Poland	Car	Toy	118	yes	[Straková et al. 2018a]
Poland	IQ cube	Toy	624	yes	[Straková et al. 2018a]
Poland	Diadem	Hair accessory	6 - 84	yes	[Straková et al. 2018a]
Poland	Hair clip	Hair accessory	97	yes	[Straková et al. 2018a]
Poland	Hair brush	Hair accessory	25	yes	[Straková et al. 2018a]
Portugal	Chess tray	Toy	1,494	yes	[Straková et al. 2018a]
Portugal	Small guitar	Toy	3,310	yes	[Straková et al. 2018a]
Portugal	Comb	Hair accessory	21 – 37	yes	[Straková et al. 2018a]
Portugal	Diadem	Hair accessory	2,491	yes	[Straková et al. 2018a]
Spain	Rubik´s cube	Toy	152	yes	[Straková et al. 2018a]
Spain	Toy gun	Toy	598	yes	[Straková et al. 2018a]
Spain	Water game	Toy	571	yes	[Straková et al. 2018a]
Spain	Hair clip	Hair accessory	764 - 853	yes	[Straková et al. 2018a]
Spain	Diadem	Hair accessory	898	yes	[Straková et al. 2018a]
Sweden	Toy camera	Toy	<LOQ		[Straková et al. 2018a]
Sweden	Toy	Toy	<LOQ		[Straková et al. 2018a]
Sweden	Diadem	Hair accessory	<LOQ - 8	no	[Straková et al. 2018a]
Sweden	Comb	Hair accessory	<LOQ - 2	no	[Straková et al. 2018a]
	Recycled articles		<1,000		[Plastic Recyc. Europe Sub. 2018]
	Recycled polymer products Axpoly ABS		< 5		[DEFRA Sub. 2018]

Country/ region	Product/product category	Product category	Concentration [mg/kg]	Evidence of other POP-BDEs	Reference
	Recycled polymer products Axpoly ABS		Non-Detect		[DEFRA Sub. 2018]
26 countries worldwide	Rubik's and Rubik's like cubes	Toy	0 - 672		[DiGangi and Straková 2016; DiGangi et al. 2017]
(7 EU countries)	Rubik's and Rubik's like cubes	Toy	0 - 400		[DiGangi et al. 2017]
Czech Republic	Thermal cup	Kitchen utensil	6		[DiGangi et al. 2017]
EU	Thermal cups	Kitchen utensil	775 - 778		[Guzzonato et al. 2017]
Czech Republic	Toys	Toy	7.03 – 2,234		[Straková et al. 2017a; Straková et al. 2017b]
International references 2009-2011	Various recycled articles		100 - 780 (0.01-0.78%)		[SE EPA Sub. Add. Info 2018]
	Vehicle components made of recycled materials	Vehicle component	No DecaBDE contained in articles produced after mid-2018 and made of recycled materials.		[DEFRA Sub. 2018; ACEA Sub. 2018a]
Argentina	Rubik's cube	Toy	0 – 359		[DiGangi et al. 2017]
Bangladesh	Rubik's cube	Toy	33 – 96		[DiGangi et al. 2017]
Belarus	Rubik's cube	Toy	134 – 153		[DiGangi et al. 2017]
Brazil	Rubik's cube	Toy	1 – 6		[DiGangi et al. 2017]
Canada	Rubik's cube	Toy	20 - 297		[DiGangi et al. 2017]
China	Rubik's cube	Toy	2 – 36		[DiGangi et al. 2017]
Czech Republic	Rubik's cube	Toy	2 – 96		[DiGangi et al. 2017]
Germany	Rubik's cube	Toy	3 – 4		[DiGangi et al. 2017]
Hungar	Rubik's cube	Toy	0 – 58		[DiGangi et al. 2017]
India	Rubik's cube	Toy	0 – 516		[DiGangi et al. 2017]
Indonesia	Rubik's cube	Toy	0 – 63		[DiGangi et al. 2017]
Japan	Rubik's cube	Toy	1 -17		[DiGangi et al. 2017]
Kenya	Rubik's cube	Toy	18 – 171		[DiGangi et al. 2017]
Mexico	Rubik's cube	Toy	17 – 152		[DiGangi et al. 2017]
Nepal	Rubik's cube	Toy	19 – 234		[DiGangi et al. 2017]
Philippines	Rubik's cube	Toy	5 – 293		[DiGangi et al. 2017]
Poland	Rubik's cube	Toy	0 - 79		[DiGangi et al. 2017]
Russia	Rubik's cube	Toy	0 – 217		[DiGangi et al. 2017]
Serbia	Rubik's cube	Toy	36 – 47		[DiGangi et al. 2017]
Slovakia	Rubik's cube	Toy	98		[DiGangi et al. 2017]
South Africa	Rubik's cube	Toy	98 – 281		[DiGangi et al. 2017]
Sri Lanka	Rubik's cube	Toy	44 – 131		[DiGangi et al. 2017]
Sweden	Rubik's cube	Toy	0		[DiGangi et al. 2017]
Thailand	Rubik's cube	Toy	21 – 23		[DiGangi et al. 2017]
UK	Rubik's cube	Toy	10 - 400		[DiGangi et al. 2017]

Table A4-2: Concentrations of decaBDE in material, articles and waste for/of EEE (Reproduced from Potrykus et al., 2019)

Country/ region	Product/product category	Product category	Waste category	Production year and country of origin	decaBDE content (**mean*** / range) [mg/kg]	Detection frequency	Evi-dence of other POP-BDEs	Reference	Comment/further info
Material									
Switzerland	FR2 laminates	EEE/material	WEEE		36 g/m²		yes	[Morf et al. 2003]	Assumptions based on literature; more data available on EEE and household appliances, but only assumptions and extrapolations
Switzerland	PE insulating foam	EEE/material	WEEE		20,000		no	[Morf et al. 2003]	
Switzerland	PE plastic sheeting	EEE/material	WEEE		100,000		yes	[Morf et al. 2003]	
Switzerland	PP plastic sheeting	EEE/material	WEEE		100,000		yes	[Morf et al. 2003]	
Switzerland	PVC plastic sheeting	EEE/material	WEEE		50,000		no	[Morf et al. 2003]	
Switzerland	plastic casings for EE products	EEE/material	WEEE	1998	115,000		yes	[Morf et al. 2003]	
China/Guagnzhou City/Pearl Delta River	Computer display casing	EEE/material	WEEE	China	**1.527**/ min. ND max. 6.08	25%	yes	[Chen et al. 2010]	
China/Guagnzhou City/Pearl Delta River	TV casing	EEE/material	WEEE	China	**7.99**/ min. ND max. 45.65	83.3 %	yes	[Chen et al. 2010]	
China/Guagnzhou City/Pearl Delta River	Computer component	EEE/material	WEEE	China	**253.9**/ min. ND max. 1512	75%	yes	[Chen et al. 2010]	
China/Guagnzhou City/Pearl Delta River	raw materials	EEE/material	WEEE	China	**108.9**; ND - 677	81.8%	yes	[Chen et al. 2010]	
Articles in use									
Norway	Flashlight (headlight)	EEE/articles	WEEE		2,800			[NO EA 2018]	
Sweden	Coating/cases for electronics	EEE/articles	WEEE	Before 2002	100 - 150,000			[SE EPA Sub. 2018]	
Sweden	Plastics from TV, Scanner and household equipment	EEE/articles	WEEE	Before 2012	30 - 70,000			[SE EPA Sub. 2018]	
Europe	Small and large Appliances	EEE/articles	WEEE		0 – 200,000			[Plastic Recyc. Europe Sub. 2018]	
	Plastic polymers in WEEE	EEE/articles	WEEE		0.20-0590			[UBA Sub. 2018]	
Netherlands	Printer	EEE/articles	WEEE		<3.1 - <5.2	17%	yes	[IVM 2013]	
Netherlands	CRT TV	EEE/articles	WEEE		<3.2 – 72,300		yes	[IVM 2013]	
Netherlands	CRT Monitor	EEE/articles	WEEE		<3		yes	[IVM 2013]	

Country/ region	Product/product category	Product category	Waste category	Production year and country of origin	decaBDE content **(mean*** / range) [mg/kg]	Detection frequency	Evidence of other POP-BDEs	Reference	Comment/further info
Netherlands	Flatscreen	EEE/articles	WEEE		<3.4		yes	[IVM 2013]	
Netherlands	Scanner	EEE/articles	WEEE		<4.8 - 320		yes	[IVM 2013]	
Turkey	computer	EEE/articles	WEEE		81 - 98	83%	yes	[Binici et al. 2013]	
Turkey	hair dryer	EEE/articles	WEEE		75 - 191	80%	yes	[Binici et al. 2013]	
Turkey	toaster	EEE/articles	WEEE		91 - 98	67%	yes	[Binici et al. 2013]	
Turkey	microwave oven	EEE/articles	WEEE		72 - 91	67%	yes	[Binici et al. 2013]	
Turkey	cable	EEE/articles	WEEE		79 - 96	100%	yes	[Binici et al. 2013]	
Japan	PC boards	EEE/articles	WEEE	2008; Japan	16 - 17		yes	[Kajiwara et al. 2011]	different methods of extraction used
Japan	Rice cooker 1	EEE/articles	WEEE	2008; Japan	11		yes	[Kajiwara et al. 2011]	different methods of extraction used
Japan	Rice cooker 2	EEE/articles	WEEE	2008; Japan	0.28 - 0.3		yes	[Kajiwara et al. 2011]	different methods of extraction used
Japan	computer mouse	EEE/articles	WEEE	2008; Japan	0.55 - 0.83		yes	[Kajiwara et al. 2011]	different methods of extraction used
India	motherboard computer	EEE/articles	WEEE	1996; Taiwan	11,583	100%	yes	[Kumari et al. 2014]	
India	electrical wire	EEE/articles	WEEE	1996; Taiwan	ND	0	no	[Kumari et al. 2014]	
Switzerland	Consumer electronics	EEE/articles	WEEE		>1,000	100%	no	[Kant. Lab. BS 2009]	
Switzerland	lighting appliances	EEE/articles	WEEE		>1,000	20%	no	[Kant. Lab. BS 2009]	
Switzerland	EEE	EEE/articles	WEEE		ND	0%	no	[Kant. Lab. BS 2009]	
Switzerland	cooling and freezing appliances (inside lining without drawers)	EEE/articles	WEEE		200	20%	yes	[Wäger et al. 2011]	
Switzerland	cooling and freezing appliances (all plastic, exept foam)	EEE/articles	WEEE		400 - 500	33%	yes	[Wäger et al. 2011]	
Switzerland	vacuum cleaner	EEE/articles	WEEE		200	100%	yes	[Wäger et al. 2011]	
Switzerland	M2 w/o cleaners	EEE/articles	WEEE		500	100%	yes	[Wäger et al. 2011]	
Switzerland	small appliances for high temperature applications	EEE/articles	WEEE		800	100%	yes	[Wäger et al. 2011]	

Country/ region	Product/product category	Product category	Waste category	Production year and country of origin	decaBDE content **(mean*** / range) [mg/kg]	Detection frequency	Evi-dence of other POP -BDEs	Reference	Comment/further info
Switzerland	CRT monitors	EEE/articles	WEEE		**3,200**; 1,000 – 7,800	100%	yes	[Wäger et al. 2011]	
Switzerland	flat screen monitors	EEE/articles	WEEE		100	33%	yes	[Wäger et al. 2011]	
Switzerland	printers	EEE/articles	WEEE		400	33%	yes	[Wäger et al. 2011]	
Switzerland	CRT TVs	EEE/articles	WEEE		**4,400**; 800 – 7,800	100%	yes	[Wäger et al. 2011]	
Nigeria	PC CRT screens	EEE/articles	WEEE	1987 – 2006; Asia, America, Europe	**800**; 0 – 54,000	4.5% (10 of 224)	yes	[Sindiku et al. 2014]	Detected levels 2,600 – 54,000 mg/kg
Nigeria	TV CRT screens	EEE/articles	WEEE	1981 – 2004; Europe, Asia	**8,600**; 0 – 237,000	15% (24 of 159)	yes	[Sindiku et al. 2014]	Detected levels 860 – 237,000 mg/kg
Japan	TV set circuit board	EEE/articles	WEEE	1989 – 1998; Japan	1.0 - 38	100%	yes	[Takigami et al. 2008]	
Japan	TV set front cabinet	EEE/articles	WEEE	1989 – 1998; Japan	0.58 – 140,000	100%	yes	[Takigami et al. 2008]	
Japan	TV set rear cabinet	EEE/articles	WEEE	1989 – 1998; Japan	1.3 – 120,000	100%	yes	[Takigami et al. 2008]	
Japan	TV set circuit board	EEE/articles	WEEE	1989 – 1998; Japan	1.0 - 38	100%	yes	[Takigami et al. 2008]	
U.S.	VCRs	EEE/articles	WEEE		9,350		yes	[Petreas Oros 2009]	
U.S.	telephones	EEE/articles	WEEE		1,300		yes	[Petreas Oros 2009]	
U.S.	radios	EEE/articles	WEEE		190		yes	[Petreas Oros 2009]	
U.S.	computers	EEE/articles	WEEE		640		yes	[Petreas Oros 2009]	
U.S.	microwave	EEE/articles	WEEE		4		yes	[Petreas Oros 2009]	
U.S.	printer	EEE/articles	WEEE		200		yes	[Petreas Oros 2009]	
U.S.	cell phone	EEE/articles	WEEE		15		yes	[Petreas Oros 2009]	
Australia	Computer	EEE/articles	WEEE		169,029	45%		[Gallen et al. 2014]	Br content; Max. value, 3% of measurement show conc. >10,000 mg/kg; 8% > 1,000 mg/kg
Australia	Electronic consumer tool	EEE/articles	WEEE		1,075	43%		[Gallen et al. 2014]	Br content; Max. value, 0% of measurement show conc. >10,000 mg/kg; 2% > 1,000 mg/kg

Country/ region	Product/product category	Product category	Waste category	Production year and country of origin	decaBDE content **(mean*** / range) [mg/kg]	Detection frequency	Evidence of other POP-BDEs	Reference	Comment/further info
Australia	LHA	EEE/articles	WEEE		94,828	43%		[Gallen et al. 2014]	Br content; Max. value, 5% of measurement show conc. >10,000 mg/kg; 7% > 1,000 mg/kg
Australia	SHA	EEE/articles	WEEE		172,645	58%		[Gallen et al. 2014]	Br content; Max. value, 9% of measurement show conc. >10,000 mg/kg; 21% > 1,000 mg/kg
Australia	Electronic other	EEE/articles	WEEE		114,422	69%		[Gallen et al. 2014]	Br content; Max. value, 23% of measurement show conc. >10,000 mg/kg; 35% > 1,000 mg/kg
Australia	Telephone	EEE/articles	WEEE		4,040	64%		[Gallen et al. 2014]	Br content; Max. value, 0% of measurement show conc. >10,000 mg/kg; 29% > 1,000 mg/kg
Australia	TV	EEE/articles	WEEE		124,868	87%		[Gallen et al. 2014]	Br content; Max. value, 62% of measurement show conc. >10,000 mg/kg; 68% > 1,000 mg/kg
Waste									
Sweden	Mixed plastic from EEE	EEE/waste	WEEE	2003 – 2006	1,000 – 20,000			[SE EPA Sub. 2018]	
Sweden	Coating/case for TV	EEE/waste	WEEE	2009	8			[SE EPA Sub. 2018]	
Sweden	Coating/case for computer	EEE/waste	WEEE	2009	15			[SE EPA Sub. 2018]	
Austria	housings of TV-screens	EEE/waste	WEEE		613 – 7,500			[AT Ministry of Sustain. and Tourism Sub. 2018a]	
Austria	housings of PC-monitors	EEE/waste	WEEE		700 – 6,300			[AT Ministry of Sustain. and Tourism Sub. 2018a]	
Switzerland	small appliances	EEE/waste	WEEE		200 – 1,200	85%	yes	[Wäger et al. 2011]	
Switzerland	small household appliances	EEE/waste	WEEE		100 - 400	67%	yes	[Wäger et al. 2011]	

Country/ region	Product/product category	Product category	Waste category	Production year and country of origin	decaBDE content (**mean*** / range) [mg/kg]	Detection frequency	Evi-dence of other POP-BDEs	Reference	Comment/further info
Switzerland	ICT and consumer equipment (screens, CRTs)	EEE/waste	WEEE		500 – 1,400	100%	yes	[Wäger et al. 2011]	
Switzerland	large household appliances	EEE/waste	WEEE		300 – 1,600	60%	yes	[Wäger et al. 2011]	
Switzerland	small household appliances	EEE/waste	WEEE		100	50%	yes	[Wäger et al. 2011]	
Switzerland	ICT equipment	EEE/waste	WEEE		100 - 900	100%	yes	[Wäger et al. 2011]	
Switzerland	consumer equipment (screens, CRTs)	EEE/waste	WEEE		900	100%	yes	[Wäger et al. 2011]	
Switzerland	sWEEE	EEE/waste	WEEE	2003; Switzerland	510		yes	[Morf et al. 2005]	
Switzerland	Cu cable scrap	EEE/waste	WEEE	2003; Switzerland	170		yes	[Morf et al. 2005]	
Switzerland	printed circuit boards	EEE/waste	WEEE	2003; Switzerland	27		yes	[Morf et al. 2005]	
Switzerland	TV housing plastic	EEE/waste	WEEE	2003; Switzerland	4,800		yes	[Morf et al. 2005]	
Switzerland	TV housing rear cover	EEE/waste	WEEE	2003; Switzerland	13,000		yes	[Morf et al. 2005]	
Switzerland	plastic parts from small e-waste	EEE/waste	WEEE	2003; Switzerland	1,800		yes	[Morf et al. 2005] quoted in [Li et al. 2013]	
China/Guang Zhou	cell phone shell	EEE/waste	WEEE		ND	0%	yes	[Chen et al. 2012]	Because the samples were collected from landfill and exposed to sunlight, degradation might have been taken place
China/Guang Zhou	computer housing	EEE/waste	WEEE		ND	0%	yes	[Chen et al. 2012]	
China/Guang Zhou	TV housing	EEE/waste	WEEE		ND	0%	yes	[Chen et al. 2012]	
China/Guang Zhou	printed circuit board	EEE/waste	WEEE		ND	0%	yes	[Chen et al. 2012]	
Netherlands	e-waste 1	EEE/waste	WEEE		1860		yes	[Ballesteros-Gómez et al. 2013]	
Netherlands	e-waste 2	EEE/waste	WEEE		71		yes	[Ballesteros-Gómez et al. 2013	
United Kingdom	TVs	EEE/waste	WEEE		21 – 138,000	78%	yes	[WRc 2012a]	
United Kingdom	industrial IT equipment	EEE/waste	WEEE		0.162 – 32,400	100%	yes	[WRc 2012a]	

Country/ region	Product/product category	Product category	Waste category	Production year and country of origin	decaBDE content **(mean*** / range) [mg/kg]	Detection frequency	Evi-dence of other POP - BDEs	Reference	Comment/further info
United Kingdom	printed circuit boards	EEE/waste	WEEE		42,500 – 129,000	100%	yes	[WRc 2012a]	
United Kingdom	digiboxes	EEE/waste	WEEE		4.40 – 5,720	100%	yes	[WRc 2012a]	
United Kingdom	large household appliances	EEE/waste	WEEE		912 – 45,700	100%	yes	[WRc 2012a]	
United Kingdom	small WEEE	EEE/waste	WEEE		778	100%	yes	[WRc 2012a]	
United Kingdom	coat hangers	EEE/waste	WEEE		22 – 80,400	100%	yes	[WRc 2012a]	
United Kingdom	fridges	EEE/waste	WEEE		79 - 155	100%	yes	[WRc 2012a]	
United Kingdom	PC monitors	EEE/waste	WEEE		6 – 13,900	100%	yes	[WRc 2012a]	
Switzerland	PC monitor casing shredder mix	EEE/waste	WEEE		40		yes	[Zennegg et al 2014]	
Switzerland	TV casing shredder mix	EEE/waste	WEEE		100		yes	[Zennegg et al 2014]	TV mix, torque rheometer (225°C for 5 min): 1,300 mg/kg
Norway	EE waste fluff	EEE/waste	WEEE		**5 - 6**	50%	yes	[COWI 2013]	
Finland	electronic plastic	EEE/waste	WEEE		60		yes	[Sinkkonen et al. 2004]	
Netherlands	WEEE shredded	EEE/waste	WEEE		6.4 – 3,300.0	92%	yes	[IVM 2013]	
Switzerland	CRT TVs and monitors	EEE/waste	WEEE		500 – 3,000		yes	[Tange and Slijkhuis, 2009]	
Switzerland	Office equipment	EEE/waste	WEEE		500 – 3,000		yes	[Tange and Slijkhuis, 2009]	
Switzerland	Refrigerators	EEE/waste	WEEE		ND – 1,000		yes	[Tange and Slijkhuis, 2009]	
Switzerland	White goods	EEE/waste	WEEE		ND – 1,000		yes	[Tange and Slijkhuis, 2009]	
Switzerland	Small domestic appliances	EEE/waste	WEEE		ND – 1,000		yes	[Tange and Slijkhuis, 2009]	
Switzerland	remainder ICT equipment	EEE/waste	WEEE		ND – 1,000		yes	[Tange and Slijkhuis, 2009]	
Switzerland	Small domestic appliances fraction A	EEE/waste	WEEE		< 0.2		yes	[Tange and Slijkhuis, 2009]	
Switzerland	toner cartridge plastics	EEE/waste	WEEE		74.8		yes	[Tange and Slijkhuis, 2009]	

Country/ region	Product/product category	Product category	Waste category	Production year and country of origin	decaBDE content (**mean*** / range) [mg/kg]	Detection frequency	Evi-dence of other POP-BDEs	Reference	Comment/further info
Switzerland	shredder TV housing material	EEE/waste	WEEE		1,615		yes	[Tange and Slijkhuis, 2009]	
Switzerland	small domestic appliances fraction B with some shredded TV housing	EEE/waste	WEEE		544		yes	[Tange and Slijkhuis, 2009]	
Switzerland	small domestic appliances fraction C	EEE/waste	WEEE		1,321		yes	[Tange and Slijkhuis, 2009]	
Austria	TV waste plastic	EEE/waste	WEEE	Before 2006	613 – 7,503	100%	yes	[Aldrian et al. 2015]	analysed with a handheld XRF
Austria	PC waste plastic	EEE/waste	WEEE	Before 2006	702 – 6,272	100%	yes	[Aldrian et al. 2015]	
Germany/Europe	single TV sets and monitor housings	EEE/waste	WEEE		NA	2 of 15 (15 of 45 FR)	yes	[Schlummer et al. 2007]	
Germany/Europe	shredded housing material from TV sets and monitors	EEE/waste	WEEE		ND – 21,000	86%	yes	[Schlummer et al. 2007]	
Germany/Europe	mixed shredder residues from WEEE	EEE/waste	WEEE		ND – 3,100	75%	yes	[Schlummer et al. 2007]	
China	e waste (printed circuit boards and plastic materials)	EEE/waste	WEEE		3.26/0.98 – 6.39		yes	[NO EA 2016]	
China	waste printed circuit boards	EEE/waste	WEEE		130		yes	[Zhou et al. 2013]	

Table A4-3: Concentrations of decaBDE in material, articles and waste of the ELV waste category (Reproduced from Potrykus et al., 2019)

Country/ region	Product/product category	Product category	Waste category	Production year and country of origin	decaBDE content ration (**mean*** / range) [mg/kg]	Detection frequency	Evidence of other POP-BDEs	Reference	Comment/ further info
Material									
Netherlands	PUF car seat (Pontiac Transport)	automotive materials	ELV	1997	522	100%	yes	[IVM 2013]	
Netherlands	seat cover (Pontiac Transport)	automotive materials	ELV	1997	22,500	100%	yes	[IVM 2013]	
Netherlands	interior (Pontiac Transport)	automotive materials	ELV	1997	18	100%	no	[IVM 2013]	
Netherlands	PUF car seat (Mazda 323)	automotive materials	ELV	1998	<1.6	100%	no	[IVM 2013]	
Netherlands	seat cover (Mazda 323)	automotive materials	ELV	1998	22,700	100%	no	[IVM 2013]	
Netherlands	interior (Mazda 323)	automotive materials	ELV	1998	52	100%	no	[IVM 2013]	
Netherlands	different car components (Europa)	automotive materials	ELV	1992 - 2000	<1.2 - <3.6	0%	no	[IVM 2013]	
Netherlands	car seats	automotive materials	ELV	1974 - 2002	<4.4 - 131	18%	no	[IVM 2013]	
Netherlands	PUF car seats	automotive materials	ELV	1992 - 1999	0.11 - 0.97	100%	yes	[IVM 2013]]	
Netherlands	seat cover (Chrysler Saratoga)	automotive materials	ELV	1991	256	100%	no	[IVM 2013]	
China/Guagnzhou City/Pearl Delta River	car interior (plastic interior, seat PUF and textile)	automotive materials	ELV		8; ND - 32.6	60%	yes	[Chen et al. 2010]	
Norway	PP/PE		ELV		n/a			[Swerea 2018]	
France	PP/PE		ELV + household		n/a			[Swerea 2018]	
France	PP/PE		ELV		n/a			[Swerea 2018]	
France	PS/ABS		ELV		140			[Swerea 2018]	

Country/ region	Product/product category	Product category	Waste category	Production year and country of origin	decaBDE content ration (**mean*** / range) [mg/kg]	Detection frequency	Evi-dence of other POP-BDEs	Reference	Comment/ further info
United Kingdom	PP		ELV		n/a			[Swerea 2018]	
United Kingdom	PP		ELV		n/a			[Swerea 2018]	
United Kingdom	PP		ELV		n/a			[Swerea 2018]	
United Kingdom	PP		ELV		n/a			[Swerea 2018]	
United Kingdom	PP		ELV		n/a			[Swerea 2018]	
United Kingdom	PP		ELV		n/a			[Swerea 2018]	
United Kingdom	PP		ELV		n/a			[Swerea 2018]	
United Kingdom	ABS		ELV		5.1			[Swerea 2018]	
Sweden	PP		ELV		n/a			[Swerea 2018]	
Articles in use									
Switzerland	cars	automotive articles	ELV		625		yes	[Morf et al. 2003]	
Switzerland	rail vehicles	automotive articles	ELV		85,000		yes	[Morf et al. 2003]	
Sweden	Textiles (in vehicles, furniture)	Automotive/furniture articles	ELV	Before 2004	200,000 - 300,000			[SE EPA Sub. 2018]	
	Automotive, E&E, Building and Construction (B&C)	Automotive/construction articles	ELV		--			[BSEF Sub. 2018]	
	Automotive	automotive articles	ELV		0 – 200,000			[Plastic Recyc. Europe Sub. 2018]	
	Plastic polymers ELV		ELV		0.2 - 590			[UBA Sub. 2018]	
Australia	Car accessoires	automotive articles	ELV		3,600	36%		[Gallen et al. 2014]	Br content; Max. value, 4% of measurement

Country/ region	Product/product category	Product category	Waste category	Production year and country of origin	decaBDE contentration (**mean*** / range) [mg/kg]	Detection frequency	Evidence of other POP-BDEs	Reference	Comment/ further info
									show conc. > 1,000 mg/kg
Australia	Car dashboard/surfaces	automotive articles	ELV		506	46%		[Gallen et al. 2014]	Br content; Max. value, 0% of measurement show conc. > 1,000 mg/kg
Waste									
Sweden	PUF from old car seats (Audi, Citroen, Dodge, Ford, Mercedes, Mitsubishi, Saab, Skoda, Subaru, Toyota, VW, Volvo)	automotive waste	ELV	1986 - 1999	ND - 2.1	88%	yes	[Niinipuu 2013]	
Norway	Soundproofing material sample 1 (Audi A6, Nissan Primera, Audi S442)	automotive waste	ELV	1993 - 1994	<50	0%	yes	[MEPEX 2012]	
Norway	Soundproofing material sample 2	automotive waste	ELV		7,000		no	[MEPEX 2012]	
Norway	Airbag material (Kia Ria)	automotive waste	ELV	2002	<50	0%	no	[MEPEX 2012]	
Norway	Seat cover material (Ford Explorer, Nissan Almera)	automotive waste	ELV	1994 - 1998	27,000		yes	[MEPEX 2012]	
Norway	Interior material (door, headlining, cover) (Kia Rio, Toyota Corolla, Volvo 240)	automotive waste	ELV	1987 - 2002	17,000	100%	no	[MEPEX 2012]	
Norway	Luggage compartment material (Mazda 626)	automotive waste	ELV	2000	<50	0%	no	[MEPEX 2012]	
Norway	Radiator, outer material (Nissan Primera)	automotive waste	ELV	2004	<50	0%	no	[MEPEX 2012]	
Norway	Printed circuit boards sample 1 (Audi A6, Audi 80, Mercedes 124 E)	automotive waste	ELV	1990 - 1994	200	100%	yes	[MEPEX 2012]	
Norway	Printed circuit boards sample 2 (Mazda 626, Mitsibishi	automotive waste	ELV	1995 - 1999	<10	0%	yes	[MEPEX 2012]	

Country/ region	Product/product category	Product category	Waste category	Production year and country of origin	decaBDE content ration (**mean*** / range) [mg/kg]	Detection frequency	Evidence of other POP-BDEs	Reference	Comment/ further info
	Carisma, BMW E39, Opel Vectra)								
Norway	Printed circuit boards sample 3 (Peugeot 406, Toyota Corolla, Volvo S40, Audi A4)	automotive waste	ELV	1995 - 1999	<10	0%	yes	[MEPEX 2012]	
Norway	Printed circuit boards sample 4 (Ford Focus, Golf, Mazda 3)	automotive waste	ELV	2000 - 2004	33	100%	yes	[MEPEX 2012]	
United Kingdom	Seat foam materials within shredder residue fraction	automotive waste	ELV		ND	0%		[BMRA 2013]	
United Kingdom	Seat foam from ELVs (BMW, Ford, Peugeot, Vauxhall)	automotive waste	ELV	1989 – 2005; Germany, America, France, UK	ND	0%	yes	[BMRA 2013]	
United Kingdom	Seat fabric from ELVs (BMW, Ford, Peugeot, Vauxhall)	automotive waste	ELV	1989 – 2005; Germany, America, France, UK	ND	0%	yes	[BMRA 2013]	
United Kingdom	cloth from car headrest	automotive waste	ELV		20	100%	yes	[WRc 2012a]	
U.S.	autoshredder waste	automotive waste	ELV		43.5		yes	[Petreas Oros 2009]	
Netherlands	car interior	automotive waste	ELV		ND	0%	yes	[Ballesteros-Gomez et al. 2013]	
Norway	fluff from mixed feedstock	automotive waste			**60**/0 - 400	54%	yes	[COWI 2013]	log-Werte (logarithmische Skala)
Norway	car fluff	automotive waste	ELV		3 - 60	69%	yes	[COWI 2013]	
Norway	complex metals fluff	automotive waste			7 - 12	40%	yes	[COWI 2013]	
United Kingdom	light ASR (foam, textile)	automotive waste	ELV		**138**/ 130 - 151		yes	[WRc addendum 2012]	
United Kingdom	mixed light plastic	automotive waste	ELV		**118**/ 11.5 - 229		yes	[WRc addendum 2012]	
United Kingdom	mixed medium density plastic	automotive waste	ELV		**2,163**/644 – 3,915		yes	[WRc addendum 2012]	

Country/ region	Product/product category	Product category	Waste category	Production year and country of origin	decaBDE content ration (**mean*** / range) [mg/kg]	Detection frequency	Evi-dence of other POP-BDEs	Reference	Comment/ further info
United Kingdom	mixed high density plastic	automotive waste	ELV		1,357	100%	yes	[WRc addendum 2012]	
Finland	light fraction of auto shredder residue	automotive waste	ELV		0.01	100%	yes	[Sinkkonen et al. 2004]	
Netherlands	plastic fraction	automotive waste	ELV	18 years (lifetime)	800		no	[ARN 2015] as cited in [NO EA 2016]	
United Kingdom	seat foam material from shredder fraction	automotive waste	ELV	1989 – 2005; Germany, America, France, UK	ND	0%	yes	[BMRA 2013]	
Japan	ASR from ELVs before 1996	automotive waste	ELV	before 1996	**406**/ 190 - 590		yes	[Japanese MoE survey 2011]	
Japan	ASR from 2000 or later	automotive waste	ELV	after 2000	**123**/ 37 - 180		yes	[Japanese MoE survey 2011]	
Ireland	ASR	automotive waste	ELV	1990 - 2006	3.50	100%	yes	[ELVES 2016]	
Ireland	ASR fine	automotive waste	ELV		2.55	100%	yes	[ELVES 2016]	
Netherlands	car shredder residues	automotive waste	ELV		0.2 - 70.0	100%	yes	[IVM 2013]	
Netherlands	WEEE/automotive shredder residues	automotive/EEE waste	WEEE/ELV		6.0 - 810	100%	yes	[IVM 2013]	
Denmark	WEEE/automotive shredder residues	automotive/EEE waste	WEEE/ELV		100	100%	yes	[Danish EPA 2014b] as cited in [NO EA 2016]	
	Vehicle equipment	automotive/EEE waste	WEEE/ELV	2009				[SE EPA Sub. 2018]	
	Automotive Shred	automotive waste	ELV		0 – 200,000			[Plastic Recyc. Europe Sub. 2018]	
	Plastic from ASR (density <1.1 g/cm³)	automotive waste	ELV		< 50			[ARN Sub. 2018]	
	Fibres originating from automotive shredder residue	automotive waste	ELV		< 50			[ARN Sub. 2018]	

Country/ region	Product/product category	Product category	Waste category	Production year and country of origin	decaBDE content ration (**mean*** / range) [mg/kg]	Detection frequency	Evidence of other POP-BDEs	Reference	Comment/ further info
	ASR	automotive waste	ELV		0.01 - 590			[DEFRA Sub. 2018; ACEA Sub. 2018a]	
	Fibres from ASR (gained by separation after shredding)	automotive waste	ELV	2017	0 - 48			[DEFRA Sub. 2018; ACEA Sub. 2018a]	
	Plastic (< 1.1 g/cm³) (gained by separation after shredding)	automotive waste	ELV	2017	0 - 12			[DEFRA Sub. 2018; ACEA Sub. 2018a]	

References for Appendix 4

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